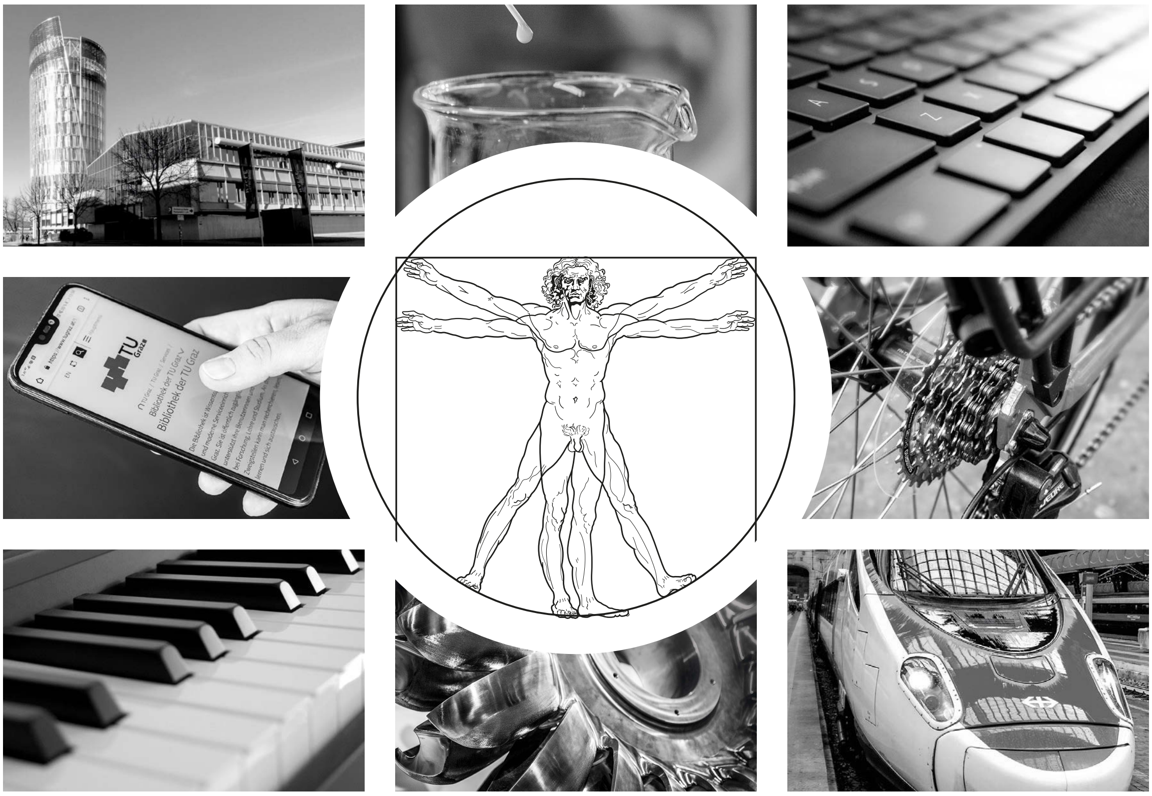
SCIENCE, TECHNOLOGY AND SOCIETY



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Critical Issues in Science, Technology, and Society Studies

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Preface

Critical Issues in Science, Technology and Society Studies

Conference Proceedings of the STS Conference Graz 2022, May 2nd – 4th

The annual STS Conference Graz provides a space for scholars from all parts of the world to present and discuss their research with peers. In their papers, the conference participants address the complex ways in which science, technology and society coevolve and mutually shape one another. Without exception, the participants of the conference aim to provide a better understanding of the world(s) in which we live. This includes the assessment of emerging technologies, the scrutiny of ethical, legal and social aspects of contemporary scientific practices as well as the transition to environmentally friendly and socially desirable techno-scientific futures.

This volume of proceeding documents is part of the work that has been presented at the 20th STS Conference in Graz in 2022. It presents the wealth of ideas discussed at this occasion and fosters collaboration. The STS Conference Graz is the joint annual conference of the Science, Technology and Society (STS) Unit at Graz University of Technology, the Interdisciplinary Research Centre for Technology, Work and Culture (IFZ) and the Institute for Advanced Studies on Science, Technology and Society (IASSTS).

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DAOs for the Creative Industries: Post-precarity Models

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Abstract. Working conditions in the creative industries have worsened under platform capitalism. However, the digitalization of work has also provided the conditions for the emergence of platform co-ops, open co-ops and blockchain-based organizations. These new organisational models have the potential to transform the current working conditions of digital workers. The overall aim of this paper is twofold: to discuss the role of these organisational models in creative industries and to shed light on alternative paths to empower workers through fairer work dynamics. To this end, we critically review illustrative case studies literature on platform co-ops, open co-ops, and blockchain-based systems in creative industries. We argue that the mutual influence between blockchain-based systems and platform co-ops can play a relevant role in the creative industries. We conclude with an open cooperativism transitional post-corporate forms scenario.

Keywords: Platform Cooperativism, Open Cooperativism, Decentralized Autonomous Organization (DAO), Blockchain-based systems, Creative Industries.

1 Introduction

The rise of platform capitalism has led to a worsening in working conditions. Precarious jobs, intermittent wages and intermittent health coverage have pervaded the life of workers. This situation has been especially noticeable in areas where freelance work is more embedded. That is the case for creative industries.

However, the digitalisation of work has also brought the emergence of platform co-ops, open co-ops and blockchain-based organisations. These new organisational models can potentially change the current relational dynamics of digital workers. One possible way to do this is by combining the features and capacities of platform co-ops and blockchain-based systems.

The proposal to hybridise platform co-ops and blockchain-based systems is not new. Scholz (2016) already opened up this possibility. More recently, Nabben *et al*. (2021) have analyzed the strengths and weaknesses of DAOs and platform co-ops, proposing feedback between the two models (Nabben *et al.*, 2021).

The overall aim of this paper is twofold: to discuss the role of these new organisational models in creative industries and to shed light on their potential to empower workers through fairer work dynamics, away from the extractivism of platform capitalism. To this end, we critically review illustrative case studies literature. We argue that the mutual influence between DAOs and platform co-ops could play an important role in the future of the creative industries. We conclude with a tentative scenario where such hybrid models could be integrated into the open cooperativism transitional post-corporate forms. The paper is organised as follows: Section 2 provides the theoretical framework. Section 3 introduces the case studies literature. Section 4 presents the discussion. Finally, Section 5 is devoted to conclusions.

2 Theoretical framework

2.1 Creative Industries and Digital Work

The most widespread definition of *creative industries* is the definition provided by the UK Department for Culture, Media and Sport: "Those industries which have their origin in individual creativity, skill and talent and which have a potential for wealth and job creation through the generation and exploitation of intellectual property" (DCMS, 1998). Previously, Adorno and Horkheimer developed the concept of Culture Industries during the 1940s (Horkheimer & Adorno, 1947), which is critical to understanding the concept of Creative Industries.

Work in the creative industries is characterised by individuality and competitiveness (de Peuter *et al.*, 2020). It is done primarily online, and the workers, usually forcible freelancers or precarious, compete for a limited number of projects, short-term contracts and funding (Ibid.). Informality, enabled by the prevailing project-based work model (Ross, 2007; Castells, 2009; Kalleberg, 2009; Arnold & Bongiovi, 2013; Merkel, 2019) and by the flexibilisation, casualisation and political deregulation of labour (Mould et al., 2014; Merkel, 2019), is another key characteristic of creative industries. Informal practices contribute to consolidating specific characteristics in the sector: thus, informal recruitment favours the overrepresentation of the middle-class white male profile (Alacovska, 2017), and the type of contract and its temporality allows companies to avoid the responsibility for training and health coverage of employees (Merkel, 2019).

Invisible labour permeates the industry: getting projects or a job depends substantially on social media presence or branding (Arvidsson et al., 2016), networking (Currid, 2007), internships (Frenette, 2013), social contacts (Siebert & Wilson, 2013), and learning practical skills (Grugulis & Stoyanova, 2011). Time invested in these areas is not formally considered work and therefore is not usually remunerated. This functions as a threshold that discriminates heavily against workers with fewer resources or childcare responsibilities (Merkel, 2019).

The generation of value through the exploitation of intellectual property is at the core of the definition of creative industries (DCMS, 1998). Digitalisation has further increased the authorship problem. With a market focused predominantly on the production of digital goods and services, monetisation by the author becomes substantially harder for two reasons: the zero marginal cost of creating and distributing copies and the presence of intermediary agents or platforms between the end-user and the author (Chalmers *et al.*, 2022). The latter foreshadows the content of the following section.

2.2 Platform Capitalism

The ambivalence of technology can lead to the reproduction of the values embedded in it, maintaining or even increasing levels of negative externalities and exploitation. Platform and surveillance capitalism are paradigmatic examples of this.

Far from resulting in a benefit to workers, the rise of platform capitalism has worsened working conditions (Mazzucato, 2018; Scholz, 2016). Competition-driven externally and mostly internally, precarious jobs, intermittent wages and intermittent health coverage have permeated workers' lives (Scholz, 2016). This has significantly affected low-skilled gig workers, who make up the vast majority of the workforce (Zwick, 2018).

Platforms consist of a digital environment that acts as an interface linking workers and users or consumers. The corporations that run them act as middlemen, charging a fee on the worker's earnings. The relationship between the proprietary platform and its vast majority of workers is far from being legally an employer-employee relationship. Under the premises of the flexibility and freedom of the digital era, the proprietary platforms advocate a freelance model. This allows them to avoid contractual obligations (Scholz, 2016). Far from empowering the worker, the proprietary platform tries to monopolise the market and isolate the workers. This isolation is twofold: isolation from the client and isolation from other workers. To this end, these platforms rely on their structure and governance. Design embedded coercion through centralisation and opacity limits the agency and autonomy of workers and enables unfair user and worker data use (Srnicek, 2017a). To this end, the platforms rely on centralised servers or data centers, and on closed-source. Top-down governance further contributes to these constraints favouring unequal distribution of resources and power (Smigiel, 2020; Scholz, 2016).

Surveillance capitalism arises from the pattern extraction performed by such proprietary platforms on the collected data (Linder, 2019; Srnicek, 2017b; Srnicek, 2017a). These patterns are monetised and/or used to predict and modify the behaviour of workers and consumers. The target behaviour encourages the maintenance of a cycle of maximising corporate profits, over-production and excess consumption (Kostakis *et al.*, 2021).

2.3 Platform Cooperativism

Platform cooperativism represents a growing alternative to platform capitalism based on the main idea of workers' shared ownership and democratic governance. Collaboration-driven internally and mostly competition-driven externally, platform co-ops constitute the application of the traditional cooperative concept to the digital environment (Scholz, 2016; Pazaitis *et al.*, 2017).

Scholz and Schneider (2016) lay the foundations of platform cooperativism through the following principles: a) anti-discriminatory open membership; b) democratic member control; b) equitable member economic participation; d) autonomy and independence; e) education, training, and information; f) cooperation among cooperatives; g) concern for the community. These more intuitive principles, attributed to Susie Cagle, are an update of those of the International Co-operative Alliance (ICA) and have been the most widely disseminated and accepted by the community.

In platform cooperativism, activism and enterprise converge. Built on ideas of social justice, solidarity, and social benefit are core features (Scholz & Schneider, 2016; Pazaitis *et al.*, 2017). Thus, for many platform co-ops, social change and the generation of fair alternatives to platform capitalism is the primary goal, over and above wealth generation (Sandoval, 2020).

2.4 Open Cooperativism

Commons-based peer production (CBPP) is a socio-economic system of production characterised by the generation of shared resources and value by groups of individuals in the absence of hierarchies and economic incentives/market prices as the driving force (Benkler, 2008). Wikipedia and the GNU/Linux operating system serve as paradigmatic examples (Benkler & Nissenbaum, 2006).

From the conjunction of CBPP and the cooperative form of organisation emerges an alternative form of socio-economic organisation: open cooperativism. Open cooperativism aims at the radical reconfiguration of social relations with the technological means of production, and its primary goal is to create a commons-oriented counter-economy (Pazaitis *et al.*, 2017). Collaboration-driven internally and externally, open cooperativism does not propose a break with platform cooperatives. It proposes to redirect them towards the common good and away from generating artificial scarcity of eminently abundant resources such as the digital commons (Bauwens & Kostakis, 2016). Finally, it also advocates integrating them into an entrepreneurial coalition composed of generative enterprises. This coalition, the productive community and the for-benefit foundation constitute the three institutions that compound the new value-creation ecosystems associated with CBPP (Bauwens *et al.*, 2017).

2.5 Blockchain & Blockchain-based Systems

The blockchain and cryptocurrency economy, spurred by the coming of the Decentralized Autonomous Organization (DAO) and the Non-fungible Tokens (NFTs), has been widely used by the 'digital wealthy' and hidden sectors of the economy, making the ethical, moral and legal uses of these new technologies, at the very least, questionable (Dyntu & Dykyi, 2018; Matherson, 2021; Østbye, 2022). However, there is an undeniable potential for blockchain in other sectors of activity.

Blockchain is a distributed and append-only ledger technology. It enables immutable and decentralised data storage without the need for a third party or trusted authority (Underwood, 2016; Wright & De Filippi, 2015; Rozas *et al.*, 2021). Blockchain's potential lies in the fact that it allows for the implementation of new infrastructure-level properties in a fully decentralised manner. Thus, it enables the direct upload and storage of code fragments/programs called smart contracts (Rozas *et al.*, 2021; Semenzin *et al.*, 2022). Smart contracts allow parties to verify whether a specific event or condition has been fulfilled.

A DAO is a blockchain-based system regulated by a set of smart contracts deployed on a public blockchain. Defining the governance structure of the organisation, the information encoded in these smart contracts mediates the interaction between the parties involved, allowing people to coordinate and self-govern themselves in a decentralised, horizontal, transparent and secure manner (Wright & De Filippi, 2015; Hassan & De Filippi, 2021).

Regarding the governance of the commons and including DAOs properties, Rozas *et al.* (2021) summarise the following properties of Blockchain: 1) tokenisation: the possibility of converting the rights to perform an action into tokens; 2) self-enforcement and formalisation of rules: the possibility of embedding organisational rules into smart contracts; 3) autonomous automatisation: the self-executing capability of smart contracts; 4) decentralisation of power over infrastructure: the fact that ownership and control are communalised due to the common ownership of the infrastructure on which they rely; 5) increasing transparency: the process of opening up organisational processes and their data by relying on the persistence and immutability of blockchain; 6) codification of trust: thanks to cryptographic primitives blockchain enables agreements without the need for third parties (Semenzin *et al.*, 2022).

In addition to smart contracts and DAOs, another innovative technology that the blockchain distributed ledger brings with it is NFTs. NFTs are blockchain-based cryptographic assets/tokens non mutually interchangeable. Its importance lies mainly in its potential to provide a public proof-of-ownership: the blockchain analogue of a certificate of authenticity or signature (Chalmers *et al.*, 2022; Chohan, 2021). Usually linked to physical or digital objects and combined with user licenses, their possibilities extend to structures and processes such as organisations and procedures.

3 Case Studies Literature in the Creative Industries

This section presents and critically reviews illustrative case studies literature on platform co-ops, open co-ops, and blockchain-based systems in the creative industries. The main objective of the section is to address the contribution of each of these organisational models to solving the problems outlined in the previous sections. The discussion is organised around the aforementioned models. Case studies have been drawn from the academic literature by purposive sampling. The only criterion used was data availability, selecting the best-documented cases. All of them are well-established initiatives, except for Plantoid, which constitutes an interesting anomaly to study due to its idiosyncratic characteristics. Leaving aside Plantoid, for which we lack data, the size of the initiatives is variable, ranging from the 100 members employed by Enspiral (Pazaitis *et al.*, 2017) to the approximately 6.5 million registered users of Freesound (Fonseca *et al.*, 2017). The main limitation of the present study is the exclusive use of secondary data. Therefore, the author cannot guarantee the correct collection and treatment of the data or the absence of bias. Finally, although this could make theoretical generalisation difficult, the author considers the sample size of selected case studies sufficient to mitigate such biases considerably.

3.1 Platform Co-ops in the Creative Industries

Platform co-ops have been addressed extensively in the academic field of organisation studies. However, sufficiently documented research cases in the creative industries sector are scarce. The following three cases are presented below: Stocksy, Doc Servizi and Société Mutuelle d'Artistes (SMart).

Although it can be assumed to be a common starting point for most platform co-ops, the Stocksy, Doc Servizi and SMart cases illustrate an intentional choice of the platform co-op model as a way out of the precariousness of the creative labour (Grayer, 2020; Martinelli *et al*., 2019; Conaty *et al.*, 2018). Nevertheless, the measures implemented to overcome it differ substantially between these co-ops: Stocksy adheres to seven principles of platform cooperativism and uses co-ownership, redistribution of profits and transparency (Papadimitropoulos, 2021; Scholz & Schneider, 2016), while Doc Servizi and SMart opt for hiring workers under contracts that remain active when employment is discontinued. Without being mutually exclusive, this second alternative has the clear advantage of providing workers with health, social and professional coverage while maintaining their autonomy (Martinelli *et al*., 2019; Conaty *et al.*, 2018).

The differences between these co-ops extend to governance. Stocksy follows a transparent online flat decision-making process. The board includes directors from each of the three classes that conform the cooperative: founders and advisors, staff, and photographers. Every member has an equal voting share and can propose resolutions (Scholz & Schneider, 2016; Papadimitropoulos, 2021). Similarly, in Doc Servizi, business and budgetary decisions are taken democratically, following the one-member, one-vote principle (Chiappa & Martinelli, 2019). Finally, SMart has moved from association toward a Foundation model (Demoustier, 2009). The Management Board of the SMart Foundation is composed of 12 members, five of whom are artists. In addition, all members are invited to the Annual General Meeting. There, they have the right to vote, according to the one-member, one-vote principle (European observatory of Social economy, 2014). Despite the differences, the common feature is a remarkable enhancement of democratic bottom-up processes compared to proprietary platform models.

Regarding their similarities, they all share their deliberately internal collaborative and solidarity nature while imbued to some degree within the capitalist market. On the one hand, the collaborative and solidarity nature largely avoids worker-worker and worker-client isolation through networks of trust, (more or less) frequent interactions focused on mutual support and even the creation of coworking physical spaces (Martinelli *et al*., 2019). On the other hand, the need to compete externally may lead them to replicate specific extractive dynamics such as the generation of artificial scarcity through the use of patents, copyright and proprietary licenses, or to internalise the prevailing values of the capitalist market and become easy targets for co-optation.

3.2 Open Co-ops in the Creative Industries

The presence in the literature of open cooperatives in the creative industries is restricted to the case of Enspiral. For illustrative purposes, we will also address two other platform co-ops which share some core features with open cooperatives: Freesound and Freesound Datasets. These two platform co-ops can be understood as proto-open co-ops.

The first shared core feature of these three cases is an orientation towards the generation of commons for the common good. Focused on the scientific and research community, and promoted by Pompeu Fabra University, Freesound and Freesound Datasets are two platform co-ops consisting of collaborative online databases. Freesound stores samples uploaded by users under Creative Commons licenses. This guarantees openness and acknowledgement for creators. Freesound Datasets uses Freesound content to generate and store open and curated evolving audio datasets to foster data-driven research approaches (Font *et al.*, 2013; Fuster & Espelt, 2017; Fonseca *et al.*, 2017). More than just a cooperative, Enspiral is a network of companies and professionals that foster social entrepreneurship. It is a CBPP system composed of three parts: the Enspiral Foundation, Enspiral Services and Enspiral Ventures. The Enspiral Foundation is the core node of the network. It is a limited liability company that works as a worker-owned co-op and reinvests all income in its social mission (Pazaitis *et al.*, 2017).

The second core feature is its openness. The my.enspiral platform software is open source and licensed under the GNU General Public License (GNU GPL). This also applies to Freesound and Freesound Datasets, both licensed under the GNU Affero General Public License (GNU AGPL). The software for all of them is publicly available in Github file repositories. However, openness in Enspiral is not limited to the purely technical structural aspect. It is a cross-cutting backbone feature that also extends to open governance and financial transparency. While governance in Freesound takes the form of an open forum moderated by researchers (Fuster & Espelt, 2017), with a section dedicated to the governance of Freesound Datasets, the most relevant decisions for Enspiral are taken by the Enspiral Foundation. As stated in its constitution, the Foundation is composed of a board of directors elected by the members of Enspiral, who can even fire them and amend the constitution. Moreover, Enspiral leadership is a fluid process. Far from a rigid hierarchy, we find a heterarchy: context-dependent fluctuating hierarchies (Pazaitis *et al.*, 2017). This symmetry helps balance the distribution of power, maximises member agency and autonomy, ensures fair data handling and avoids the dynamics of surveillance capitalism while guaranteeing the platform's improvement and replicability.

Another differentiating aspect is that both Freesound and Freesound Datasets limit themselves to the generation of digital commons, employing open licenses and engaging in what Bauwens and Kostakis (2014) term as the communism of capital. This makes it difficult to make a living in the creative industries in two ways. On the one hand, if the type of license used prohibits the commercial exploitation of the derivative work, the members of the cooperative cannot monetise it in order to contribute to their livelihood. This situation contributes to keeping part of the work done in the creative industries invisible and fosters the gap between the generation of common value and the generation of stable monetary income. Ultimately, the involvement of members and the value generated are restricted. On the other hand, if the work is in the public domain or only requires attribution of authorship, the benefits extracted from it will not be redistributed among the members of the cooperative. What may appear to be freedom encourages unfair exploitation by large companies, who use open source as a cheap lab and often as a preliminary step to the closure of the derivative code. Commons-based reciprocity licenses, which allow a different type of use depending on the recipient, could prevent predation by non-commons oriented companies while enabling the continuity of the open co-op model and the livelihood of its members (Bauwens & Kostakis, 2014).

3.3 Blockchain Based-systems in the Creative Industries

Since the appearance of the Bitcoin whitepaper (Nakamoto, 2008), the academic literature on the Blockchain has continued to grow. However, contrary to what might appear, the case study literature on blockchain-based systems in the creative industries is not abundant. We will now present the two sufficiently documented cases we have come across: DADA and Plantoid.

DADA is an art creation platform and an artist collective. It was the first decentralised art marketplace on the Ethereum blockchain and the first with automatised royalties encoded into their smart contracts. The DADA platform acts as an environment where members interact through the visual medium and exchange digital artworks minted as NFTs. When an NFT is sold, the smart contract distributes 70 per cent of the profits to the artist and 30 per cent to DADA for the maintenance and development of the platform. If the NFT is resold, the smart contract automatically directs 60 per cent to the owner, 10 per cent to DADA, and 30 per cent to the artist (Potts & Rennie, 2019). This process constitutes a recurring loop. In addition to contributing to the platform's survival, this automatised redistribution of profits puts the artist at the centre and helps to discourage speculation.

Designed and implemented by the artist/researcher Primavera De Filippi, Plantoid is a DAO. Conceived as a vegetable analogue of an android, it is a hybrid life-form that simultaneously inhabits two environments: the physical environment (or physical world) and the digital environment (or numeric world). It consists of two essential components: the body and the spirit. The body consists of a plant-like metal sculpture controlled by a

Raspberry Pi, which reacts to users' cryptocurrency donations with music, dance or a light display. The spirit (or soul) only exists in the digital world as a set of smart contracts deployed on the Ethereum blockchain. This software, autonomous and executed decentrally among the network nodes, is inheritable. Encoded in it are the rules that determine the possible interactions with humans, those that allow governance by contributors, those that redistribute profits, and those that preserve the authorship of the creators (Primavera De Filippi, 2020; Potts & Rennie, 2019).
Despite the different nature of the analysed cases, both cases share some characteristics. On the one hand, the decentralised infrastructure on which they rely. On the other hand, the use of smart contracts and redistributive algorithms.

4 Discussion

Platform co-ops such as Doc Servizi and SMart alleviate precarity in the creative industries by providing their freelancer members with contracts that offer them health coverage, a stable income and salaried status while maintaining their autonomy. Platform co-op members' employee status can help counterbalance the informality of the sector. The three platform co-ops presented significantly improve bottom-up democratic processes compared to proprietary platform models. Clearly of an internal collaborative nature, these platform co-ops also solve the problem of isolation on both sides: isolation between workers and isolation from the customer. This, together with co-ownership, results in clear empowerment of workers, who take back control over their work. However, since these platform co-ops compete externally in the capitalist market, the risk (or even the need) of replicating capitalist extractive practices, internalising capitalist mindsets or being co-opted remains.
Focused on weaving a collaborative network of generative ecosystems outside the capitalist market, open co-ops such as Enspiral solve the aforementioned risks. With openness as a structural, governance and financial backbone, open co-ops break down the unequal distribution of power and resources. This maximises member agency and autonomy, ensures fair data handling and avoids the dynamics of surveillance capitalism while guaranteeing the platform's improvement and replicability. In turn, through the use of commons-based reciprocity licences, open cooperatives provide a plausible mechanism to avoid predation by non-commons-oriented enterprises while allowing for the continuity of the open cooperative model and the livelihood of its members (Bauwens & Kostakis, 2014). By not drawing a line between common value generation and paid work, open co-ops also minimise the invisibilisation of work characteristic of creative industries while encouraging members to stay involved.
Finally, blockchain-based systems provide decentralised data storage and processing/computation prescinding from the proprietary central server or data center structure. The communisation of resources contributes, together with the transparency and immutability that the distributed ledger of blockchain exhibits, to eliminating unequal

distribution of power and unfair use of data. Through that transparency and immutability, Blockchain based-systems also provide trust. Trust makes it easier to join projects in an increasingly global industry (Scholz, 2016). In addition, this distributed ledger brings some innovations, such as smart contracts, redistributive algorithms and NFTs.
Both DADA and Plantoid encode core features in smart contracts. The possibility of encoding in the smart contracts of a DAO the rules governing platform co-ops opens up many possibilities in the creative industries. Thus, DAOs could function as an autonomous infrastructure that would allow tasks to be transparently allocated through standardised criteria, with remuneration calculated according to objective scales, without workers necessarily being located in a particular country or having to deal with legal intricacies and with an automatised redistribution of profits through automatised royalties/redistributive algorithms. Furthermore, the combined use of NFTs and licences could help solve the authorship problems in creative industries.
To conclude, some of these platform co-ops implemented on DAOs, focused on the generation of commons and with openness as the backbone, could be integrated into the network of generative ecosystems characteristic of open cooperatives such as Enspiral. In addition to the advantages seen above, this would provide the possibility of self-replication of nodes through code inheritance as in the case of Plantoid, the possibility of generating decentralised markets such as DADA, and new applications for NFTs through the joint use of commons-based reciprocal licenses.
As we can see, although we find concrete implementations that solve many of the problems characteristic of the creative industries, there is no initiative that meets the necessary characteristics to solve them all.

5 Conclusions

Although platform capitalism has considerably worsened the (already bad) situation of work in the creative industries, the new models born out of the digitalisation of work have proven to alleviate to a large extent many of the problems already present, aggravated or originated by it. However, no single model solves all problems. Rather than being mutually exclusive models, they are complementary. Blockchain-based systems, particularly DAOs, show features that could enhance the potential of platform and open co-ops. We propose to hybridise these models by encoding the platform co-op rules in the set of smart contracts of a DAO. We posit a hypothetical situation where DAO-enhanced platform co-ops embedded in the creative industries capitalist market would coexist with DAO-enhanced open co-ops. The latter would consist of networks or coalitions of DAO-enhanced platform co-ops focused on generating common goods and with openness at their core, and with the ultimate goal of creating a commons-oriented counter-economy (Bauwens & Kostakis, 2014).
Finally, using blockchain as infrastructure, DAOs as part of the technological/algorithmic governance of platform and open co-ops, and NFTs and redistributive algorithms as a

means of safeguarding workers' rights would also provide the application of these technologies for the general interest, creation of wealth, and a post-precarity frame for digital labour.

References

Alacovska, A., 2017. The gendering power of genres: How female Scandinavian crime fiction writers experience professional authorship. *Organization*, *24*(3), pp.377-396.

Arnold, D. and Bongiovi, J.R., 2013. Precarious, informalizing, and flexible work: Transforming concepts and understandings. *American Behavioral Scientist*, *57*(3), pp.289-308.

Arvidsson, A., Gandini, A. and Bandinelli, C., 2016. Self-branding amongst freelance knowledge workers.

Bauwens, M. and Kostakis, V., 2014. From the communism of capital to capital for the commons: Towards an open co-operativism. *tripleC: Communication, Capitalism & Critique. Open Access Journal for a Global Sustainable Information Society*, *12*(1), pp.356-361.

Bauwens, M. and Kostakis, V., 2016. Why platform co-ops should be open co-ops. *Ours to hack and to own: The rise of platform cooperativism, a new vision for the future of work and a fairer Internet*, pp.163-166.

Bauwens, M., Kostakis, V., Troncoso, S. and Utratel, A.M., 2017. Commons Transition and P2P: a primer. *Transnational Institute and P2P Foundation http://commonstransition. org/commons-transition-p2p-primer/(last accessed 21 March 2019)*.

Benkler, Y. and Nissenbaum, H., 2006. Commons-based peer production and virtue. *Journal of political philosophy*, *14*(4)

Benkler, Y., 2008. The wealth of networks. In *The Wealth of Networks*. Yale university press.

Castells, M., 2009. *The rise of the network society*. John wiley & sons.

Chalmers, D., Fisch, C., Matthews, R., Quinn, W. and Recker, J., 2022. Beyond the bubble: Will NFTs and digital proof of ownership empower creative industry entrepreneurs?. *Journal of Business Venturing Insights*, *17*, p.e00309.

Chiappa, C. and Martinelli, F., 2019. Doc Servizi e la sua rete: un esempio di alleanza tra cooperazione e sindacati nel mondo dello spettacolo, della creatività e della cultura. *Quaderni di Rassegna Sindacale*, *13*(2), pp.109-123.

Chohan, U.W., 2021. Non-fungible tokens: Blockchains, scarcity, and value. *Critical Blockchain Research Initiative (CBRI) Working Papers*.

Conaty, P., Bird, A. and Ross, C., 2018. Working together. *Trade union and co-operative innovations for precarious workers, Manchester, Co-operatives UK*.

Currid, E., 2007. The warhol economy. In *The Warhol Economy*. Princeton University Press.

DCMS, U., 1998. Creative industries mapping document. *UK DCMS*, *3*.

de Filippi, P., 2020. PLANTOÏDE: UNE FORME DE VIE FONDÉE SUR LA BLOCKCHAIN.

Demoustier, D., 2009. SmART: un intermédiaire au service de la consolidation ou de la normalisation des pratiques culturelles?. *L'Observatoire*, (1), pp.64-67.

de Peuter, G., Sandoval Gomez, M., Dreyer, B. and Szaflarska, A., 2020. Sharing Like We Mean It: Working Co-operatively in the Cultural and Tech Sectors.

Dyntu, V. and Dykyi, O., 2018. Cryptocurrency in the system of money laundering. *Baltic Journal of Economic Studies*, *4*(5), pp.75-81.

European observatory of Social economy. (2014). *SMart, un acteur innovant de soutien aux artistes et à la création artistique et un réseau européen en construction.* https://www.ess-europe.eu/en/bonnepratique/smart-un-acteur-innovant-de-soutien-aux-artistes-et-la-creation-artistique-et-un

Fonseca, E., Pons Puig, J., Favory, X., Font Corbera, F., Bogdanov, D., Ferraro, A., Oramas, S., Porter, A. and Serra, X., 2017. Freesound datasets: a platform for the creation of open audio datasets. In *Hu X, Cunningham SJ, Turnbull D, Duan Z, editors. Proceedings of the 18th ISMIR Conference; 2017 oct 23-27; Suzhou, China.[Canada]: International Society for Music Information Retrieval; 2017. p. 486-93*. International Society for Music Information Retrieval (ISMIR).

Font, F., Roma, G. and Serra, X., 2013, October. Freesound technical demo. In *Proceedings of the 21st ACM international conference on Multimedia* (pp. 411-412).

Frenette, A., 2013. Making the intern economy: Role and career challenges of the music industry intern. *Work and Occupations*, *40*(4), pp.364-397.

Fuster, M. and Espelt, R., 2017. Platform Cooperativism Holistic Characterization and Delimitation: 10 Cases of Barcelona Ecosystem. *Re-embedding the Social: Cooperatives, Political Consumerism and Alternative Lifestyles. SASE*.

Grayer, S., 2020. *Stocksy United: A case study of co-operation in the cultural industries* (Doctoral dissertation, Communication, Art & Technology: School of Communication).

Grugulis, I. and Stoyanova, D., 2011. The missing middle: communities of practice in a freelance labour market. *Work, employment and society*, *25*(2), pp.342-351.

Hassan, S. and De Filippi, P., 2021. Decentralized Autonomous Organization. *Internet Policy Review*, *10*(2), pp.1-10.

Horkheimer, M. and Adorno, T.W., 1947. Dialektik der Aufklärung. Philosophische Fragmente [Dialectic of Enlightenment. Philosophical Fragments]. *Amsterdam, the Netherland: Querido*.

Kalleberg, A.L., 2009. Precarious work, insecure workers: Employment relations in transition. *American sociological review*, *74*(1), pp.1-22.

Kostakis, V., Giotitsas, C., Niaros, V., 2021 (forthcoming). Beyond global versus local Illuminating a cosmolocal framework for convivial technology development. Urban Studies xx(xx), xxx-xxx.

Linder, T., 2019. Surveillance capitalism and platform policing: the surveillant assemblage-as-a-service. *Surveillance & Society*, *17*(1/2), pp.76-82.

Martinelli, F., Bozzoni, S., Caroli, S., Tamascelli, F., Guerini, G., 2019. Platform Cooperativism in Italy and in Europe (CIRIEC Working papers No. 2019/027), CIRIEC Working papers. CIRIEC, Liège. https://doi.org/10.25518/ciriec.wp201927

Matherson, N., 2021. *The Driving Force of Cryptocurrency and Money Laundering* (Doctoral dissertation, Utica College).

Mazzucato, M., 2018. *The value of everything: Making and taking in the global economy*. Hachette UK.

Merkel, J., 2019. 'Freelance isn't free.'Co-working as a critical urban practice to cope with informality in creative labour markets. *Urban Studies*, *56*(3), pp.526-547.

Mould, O., Vorley, T. and Liu, K., 2014. Invisible creativity? Highlighting the hidden impact of freelancing in London's creative industries. *European Planning Studies*, *22*(12), pp.2436-2455.

Nabben, K., Puspasari, N., Kelleher, M. and Sanjay, S., 2021. Grounding decentralised technologies in cooperative principles: What can "Decentralised Autonomous Organisations"(DAOs) and platform cooperatives learn from each other?. *Available at SSRN*.

Nakamoto, S., 2008. Bitcoin: A peer-to-peer electronic cash system. *Decentralized Business Review*, p.21260.

Østbye, P., 2022. Exploring The Role of Law in The Governance of Cryptocurrency Systems and Why Limited Liability DAOs might be a Bad Idea. *Available at SSRN 4007547*.

Papadimitropoulos, E., 2021. Platform Capitalism, Platform Cooperativism, and the Commons. *Rethinking Marxism*, *33*(2), pp.246-262.

Pazaitis, A., Kostakis, V. and Bauwens, M., 2017. Digital economy and the rise of open cooperativism: the case of the Enspiral Network. *Transfer: European Review of Labour and Research*, *23*(2), pp.177-192.

Potts, J. and Rennie, E., 2019. Web3 and the creative industries: how blockchains are reshaping business models. In *A Research Agenda for Creative Industries*. Edward Elgar Publishing.

Rozas, D., Tenorio-Fornés, A., Díaz-Molina, S. and Hassan, S., 2021. When Ostrom meets blockchain: exploring the potentials of blockchain for commons governance. *SAGE Open*, *11*(1), p.21582440211002526.

Sandoval, M., 2020. Entrepreneurial activism? Platform cooperativism between subversion and co-optation. *Critical Sociology*, *46*(6), pp.801-817.

Scholz, T., 2016. Platform cooperativism. *Challenging the corporate sharing economy. New York, NY: Rosa Luxemburg Foundation*.

Scholz, T. and Schneider, N., 2016. Ours To Hack and Own: The Rise of Platform Cooperatives.

Semenzin, S., Rozas, D. and Collado, S.H., 2022. Blockchain-based application at a governmental level: disruption or illusion? The case of Estonia. *SocArXiv. March*, *3*.

Siebert, S. and Wilson, F., 2013. All work and no pay: consequences of unpaid work in the creative industries. *Work, employment and society*, *27*(4), pp.711-721.

Smigiel, C. (2020). Why did it not work? Reflections on regulating Airbnb and the complexity and agency of platform capitalism. *Geographica Helvetica*, *75*(3), 253-257.

Srnicek, N., 2017a. The challenges of platform capitalism: Understanding the logic of a new business model. *Juncture*, *23*(4), pp.254-257.

Srnicek, N., 2017b. *Platform capitalism*. John Wiley & Sons.

Underwood, S., 2016. Blockchain beyond bitcoin. *Communications of the ACM*, *59*(11), pp.15-17.

Wright, A. and De Filippi, P., 2015. Decentralized blockchain technology and the rise of lex cryptographia. *Available at SSRN 2580664*.

Zwick, A., 2018. Welcome to the Gig Economy: Neoliberal industrial relations and the case of Uber. *GeoJournal*, *83*(4), pp.679-691.

Cargo Bikes for Sustainable Last Mile City Logistics

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Abstract. Climate change, increasing urbanization and growing transport volumes are challenges cities nowadays have to face. Especially the large number of parcels due to the growing e-commerce sector which need to be delivered in densely populated urban areas cause several negative impacts like air pollution, noise and congestion – all reducing the quality of life. One way of reducing these negative externalities of logistics activities in urban areas is the use of small and emission-free vehicles. In this paper, we give an insight into the efficient and effective use of cargo bikes for sustainable city logistics based on a number of case studies. We investigate the challenges and opportunities encountered in last mile logistics processes induced by small environmentally friendly vehicles, such as cargo bikes. Several best practice examples are presented to underline the findings and give an overview of the application areas of cargo bikes. The cases undermine that a priori planning allows to successfully implement logistics processes with cargo bikes, optimizing not only ecological and social aspects, but also achieving economic benefits.

1 Introduction

Today cities are confronted with several challenges - like increasing urbanization and growing transport volumes - related to climate change. The European Union has therefore launched the ‘100 climate-neutral and smart cities’ mission, to trigger a development and transformation to climate-neutrality in urban areas (European Commission et al., 2020).

As the transport sector is responsible for about a quarter of all greenhouse gas emissions in the European Union and the urbanization level is about 75% (European Union, 2020; Szmigiera, 2021), more sustainable distribution schemes for logistics activities in cities are important means on the way to a climate-neutral urban future. To achieve this, small alternatively-fueled vehicles, like cargo bikes, seem to be an appropriate mode of transport in urban areas, since they cannot only reduce logistics-related greenhouse gas emissions but also other harmful pollutants like particulate matters or nitrogen oxides. Furthermore, such vehicles can contribute to the mitigation of congestion and noise in

cities. Despite these benefits of cargo bikes as means of transport also some challenges of these vehicles need to be considered when planning to use them for the delivery of goods.
The remainder of the paper is organized as follows. Chapter 2 presents the related work, while Chapter 3 introduces the methodological approach. Benefits and challenges of using cargo bikes for city logistics in general are dealt with in Chapter 4, and Chapter 5 describes related findings based on a number of case studies. Finally, Chapter 6 concludes the paper.

2 Related work and settings

The use of cargo bikes is well-suited for last mile distribution of goods in urban areas, enforced by an increase in e-commerce, high cost of last mile delivery and time pressure. Successfully applying cargo bikes in a logistics environment is strongly related to technological developments. The latter enable efficient and effective planning and implementation, while considering societal needs and environmental requirements. Investigations show that innovative delivery concepts can benefit companies and the quality of life in cities (cf. Arnold et al., 2018).
In a circular economy, the life cycle of products is extended and waste is reduced to a minimum. By efficiently utilizing transport capacities (i.e., avoiding empty trips, reducing traffic), resources can be preserved in last mile city logistics. The circular economy is a model of production and consumption in which existing materials and resources are shared, leased, reused, repaired, refurbished and recycled for as long as possible. Resources and materials are productively (re-)used in order to continue generating added value. The circular economy is in contrast to the traditional, linear economic model (European Parliament, 2015).
For a comprehensive survey of alternative last mile delivery concepts (i.e., all logistics activities related to the delivery of shipments to customers in urban areas), please refer to Boysen et al. (2021). The authors subsume last mile delivery as shipments, starting at a location point (i.e., storage facility) in an urban area, such as a central depot after long-haul transportation, and ending at the final customer's preferred destination point (Boysen et al., 2021).
The successful use of cargo bikes in last mile delivery operations has been investigated by several authors in a theoretical way. Arnold et al. (2018) compare cargo bike systems with other delivery concepts, i.e., vans and self-service concepts, in a simulation study based on the daily distribution activities of a logistics service provider from Antwerp (Belgium). Their results show that, compared to home delivery via vans, cargo bikes can lead to a decrease in external costs, i.e., emissions, noise, and congestion, by 40% per delivery compared to traditional home delivery via vans.
Gruber et al. (2014) observed whether electric cargo bikes were a good alternative for urban freight delivery via courier services. They analysed the potential market for electric

cargo bikes, the organization of the market and the perception of electric cargo bikes by bike and car messengers. According to the authors, electric cargo bikes are well suited for courier shipments and in urban areas, successfully facing problems like congestion and limited access areas due to environmental zones or delivery period restrictions. Their potential market is positioned between bikes and cars in terms of cost, payload and range. The authors further found that the willingness to use electric cargo bikes is determined by factors such as the electric range, the purchase price and the available information.

Enthoven et al. (2020) present a city logistics problem with cargo bikes and parcel lockers. They investigate a two-echelon vehicle routing problem, where trucks transport goods from a single depot either to covering locations, such as parcel lockers, where customers can pick up goods themselves, or to satellite locations, where goods are transferred to zero-emission vehicles (such as cargo bikes) and delivered to final customers. Computational results indicate that customers in the same area are best-served either via cargo-bikes or parcel lockers.

Dybdalen and Ryeng (2021) investigate whether cargo bikes can operate efficiently in northern climates and on winter roads, based on a case study from Trondheim, Norway. The authors observed that while the average velocity was lower for winter trips than for spring trips, despite snow, ice, slush and low temperatures cargo bikes can operate fully feasible on winter roads for urban delivery. Success factors include the design of the cargo bike, durable parts, larger wheels and better illumination, sufficient clothing and good planning, as well as an increase in the amount of bicycle lanes and urban consolidation centres or micro depots.

Assmann et al. (2020) examine different strategies for the location of urban transhipment points and their effect on traffic, carbon footprint, and air quality. The authors conclude that the use of cargo bikes for courier, express, and parcel deliveries in urban areas could reduce greenhouse gas, particulate matter, and nitrogen oxides emissions significantly. The authors point out that cargo bike delivery networks are dominantly seen as a means to improve liveability, e.g., by reducing traffic.

Browne et al. (2011) investigate kilometres travelled in a distribution scheme, related to the space occupied by vehicles performing on-street deliveries, as well as total kerbside time. They find that the space occupied can be reduced through consolidation and the use of smaller vehicles, further reducing the impact of freight operations on traffic congestion. The authors calculate the effect of different distribution systems on road space requirements by assessing the number of operating hours of the vehicles and the vehicle footprint (square meters) in order to derive the total road space and time occupied.

Vasiutina et al. (2021) provide a literature review, investigating the benefits and drawbacks of integrating cargo bikes in urban logistics schemes. The authors examine different methodologies and techniques to evaluate the impact of cargo bikes on the environment. They present studies confirming the potential of cargo bikes to serve as sustainable substitution for conventional delivery vehicles. Their literature review shows that cargo bikes are best suited for last mile delivery in cities, especially in districts with traffic restrictions and high population density.

3 Methodological approach

To investigate the potential of cargo bike usage for last mile delivery with a special focus on the situation in Austria a mixed-methods approach was chosen:

- An in-depth desk-recherche combined with semi-structured expert interviews with 23 experts from different fields related to sustainable last mile delivery in cities was conducted A content-analysis of all interviews based on Mayring (2010) was applied to gather all relevant statements from the interviews with respect to benefits and challenges of cargo bikes.
- Metaheuristics for specific vehicle routing problems were implemented and tested on real-world problems to find out the impact of transfers between vehicles as well as of bundling goods.
- An Analytic Hierarchy Process was developed and applied to find appropriate locations for hubs in a city to consolidate goods. The perspectives of different stakeholders were integrated in the process as described in more detail in Chapter 5.3.
- A pilot study was conducted in Innsbruck to test the theoretical findings in a practical setting. During four weeks parcels were delivered by cargo bikes in a selected area in the city centre of Innsbruck. The case study was conducted in cooperation with a parcel delivery company which provided the cargo bike drivers with a specific number of parcels (about 150 per day).
- Impact evaluation was based on scenarios modelling the status quo as well as the situation after the implementation. Standard vehicle routing problems were solved for both scenarios and then compared with respect to kilometres driven, number of vehicles required and emissions caused.

Combining the findings by these methods enabled us to draw conclusions from a theoretical as well as a practical point of view.

4 Benefits and challenges of using cargo bikes

While cargo bikes are particularly flexible and fast vehicles in dense urban areas, they possess a comparatively restricted loading capacity and have a potentially limited operating range. Therefore, logistics processes need to be adapted for the use of cargo bikes, which comes along with some additional challenges, such as the selection of the appropriate cargo bike type, the suitability of the products to be transported or the proper delivery routes and radius.

4.1 Benefits of cargo bike usage

Cargo bikes are – as normal bikes – vehicles moved by muscular strength. Even in case of electrically assisted ones which are more appropriate when transporting heavier goods and/or in hilly areas, these vehicles don't cause emissions at the place of use. Besides being emission-free, this type of vehicles is also noiseless and hence a significant improvement in urban traffic which is usually coined by a lot of noise.

Due to their shape, being either two- or three-wheelers, cargo bikes require much less operating space than conventional vehicles or vans. Considering that conventional vehicles might cause congestion, the required space per request is even larger, compared to a cargo bike. The required space per vehicle or per request can be an important key performance indicator for decision makers. The less space is required by vehicles, the more space can be occupied by citizens, used as shared spaces or for greening the cities and regions. This can lead to further social advantages, such as a reduction in conflicts between freight delivery and personal mobility (cf. Browne et al., 2011).

Another advantage of cargo bikes is the flexibility in traffic situations. Depending on the type of the cargo bike additional infrastructure, like bike lanes or one-way streets in both directions, can be used. This also results in cargo bikes being hardly affected by congestion. Hence, a cargo bike can be faster in dense traffic than cars or vans. Thus, the reliability of cargo bikes in freight delivery can be guaranteed and delivery time windows can be respected.

Finding a parking space is also much easier for a cargo bike than for conventional delivery vehicles. In case of broad enough pavements, cargo bikes may even be parked there. Hence, less time has to be wasted for finding an appropriate parking space and situations of delivery vehicles parked in second lane can be avoided.

Eventually, it should be mentioned that for driving a cargo bike no driving license is required. This is especially beneficial nowadays when finding drivers for trucks and vans becomes more and more difficult (Anderluh et al., 2016). In addition, cargo bike riders gain health benefits by moving actively, i.e., using their muscles while riding the bike. Active mobility refers to means of transport that rely on muscle strength, such as cycling. This has a positive impact on health status, it helps to reduce greenhouse gas emissions and thereby counteract climate change (Seel et al., 2022).

4.2 Challenges of cargo bike usage

Cargo bikes as flexible and small vehicles have a limited load capacity and also a limited operating range. These are two drawbacks of such vehicles that need to be considered when planning to integrate them in urban distribution schemes. Additional measures like adapted routing algorithms or the implementation of micro depots within an urban area, which can be used as intermediate storage facilities but also to consolidate deliveries, need to be taken into account to make it a success. Distribution schemes might be

organized in several echelons, to efficiently put cargo bikes into operation (cf. Nolz et al., 2020).
The appropriate cargo bike type needs to be selected for the delivery task at hand. This includes the appropriate size of the bike as well as the load box. Cargo bikes can have two or three wheels, the load box can be located in the front of the bike or at the back. The load box can be dedicated to transport objects as big and heavy as washing machines, or small items such as parcels. In addition, cargo bikes can be purely manual or electrically assisted. In regions, where delivery trips include steep segments, hills or generally long distances, electric cargo bikes are more appropriate.
Further challenges are connected to the topography of the delivery area and the weather conditions. While hilly regions can be solved by using electrically assisted bikes and rainy/snowy weather just requires appropriate equipment for drivers and maintenance for bikes, heat and icy streets are the two situations that remain a challenge in using cargo bikes for delivery (Anderluh et al., 2016).
Some of the mentioned challenges and issues can still be overcome by integrating cargo bikes into a heterogeneous vehicle fleet. In a combined distribution scheme with (electric) vans, cargo bikes can be efficiently used for delivery operations where appropriate, i.e., where their benefits in terms of flexibility and sustainability can be exploited. The disadvantages of cargo bikes regarding the limited driving range or loading capacity can be overcome by applying larger vehicles for the concerned requests / tasks (Anderluh et al., 2017).

5 Best Practices

Benefits and challenges of cargo bikes have to be thoroughly evaluated when planning to integrate these emission-free and flexible vehicles in urban logistics processes. Several case studies show the potential of a significant decrease of transport-related cost caused by freight delivery in urban areas.

5.1 Benefitting from transfers of shipments between vehicles

As mentioned in Section 4.2., cargo bikes are flexible, small vehicles but have a limited load capacity and also a limited operating range. Therefore, it can be beneficial to incorporate transfers of shipments between vehicles for last mile distribution. By these means, opportunities of using cargo bikes are exploited with respect to all aspects of sustainability, namely economic, ecological and social aspects. Details of this distribution scheme are explained as follows.
For logistics activities in inner-city areas, a mixed fleet of cargo bikes and (electric) vans are considered, which are placed at a so-called micro hub in the city centre. Goods can be transported with these vehicles, either from the micro hub or directly from pickup points to delivery points. Deliveries have to occur within (soft) time windows, which are determined by the final customers. In order to respect the time windows and the cargo

bike capacities, while at the same time minimizing total cost, goods can be transferred from one vehicle to another. Therefore, either a spatial-temporal synchronization of the vehicles has to be ensured if goods are directly transferred (on the route), or a temporary storage facility is needed. As a temporary storage facility, the micro hub can be used. However, this implies additional storage cost given a limited storage space in inner-city areas. On the contrary, the direct transfer requires thorough planning, since two vehicles have to meet at the same place and at the same time (please note that some waiting time is allowed, i.e., a few minutes).

Solutions to this problem are generated with respect to total cost, including economic, ecological and social criteria. Economic cost is measured based on the required distance and time for distribution. Ecological cost includes the induced carbon emissions of distribution. Social cost reflects the inconvenience and the threat caused by conventional vehicles in road traffic for human beings. Any traversal of road segments, where vulnerable groups are present is penalized with additional distance or time for delivery. A transfer from a van to a cargo bike could for example be beneficial to reduce social cost. This is especially relevant in areas where vulnerable groups are present, such as schools or homes for elderly people. In contrast to vans, this threat can be alleviated by traversing an area with cargo bikes.

Results of this investigation show that the synchronization between vehicles can be beneficial if a minimum number of requests are transported. Short time windows have an impact on the effects of synchronization. With an increase in the number of requests, the number of transferred requests increases as well. Ecological and economic costs have higher impact on synchronization than social costs, given the cost settings in the study. Especially in a mixed fleet consisting of both cargo bikes and vans, synchronization plays an important role in minimizing ecological cost. Temporary storage of goods can lead to an improvement of total cost if a minimum number of requests have to be completed. Storage pays off in the case of a cargo bike fleet or a mixed fleet (KoopHubs project, 2018).

5.2 Applicability of cargo bikes for parcel delivery in mid-size cities

In the field of parcel delivery in large cities, cargo bikes can already be seen on the streets as an example of city logistics measures. Several best practices can be found in cities like Vienna or Munich, but also mid-size cities can serve as application areas for cargo bike usage in parcel delivery.

A four-week pilot test in summer 2021 in the city of Innsbruck proofed the applicability of cargo bikes in delivering parcels of a logistics service provider to addresses in and around the historic centre of the city. Appropriate parcels with respect to delivery area, size and weight were pre-selected at the depot of the company, brought by a van to an intermediate storage facility near the city centre and then delivered by three different types of cargo bikes to the final customers.

Results of the pilot test showed that even for this small delivery area with about 150 parcels a day 1.5 tons CO_2 emissions could be avoided per year. An additional positive impact lies in the fact that about 570 van-kilometres could be replaced by cargo bikes per year (extrapolated based on the savings of emissions based on the van kilometres saved during the pilot test).

A major challenge in the pilot test was finding an appropriate location for the intermediate storage facility. For the test phase a number of potential locations was named but the only available location (that is, not too expensive and useable during the test phase) was located more than one kilometre away from the delivery area. Therefore, cargo bike drivers had to drive a rather long distance before they could start delivering parcels. Hence, this needs to be improved for a long-term application.

Additional potential for improvements can be found in the selection of the final customers for the cargo bikes. In the pilot phase customers in the historic city centre were chosen, but these were mainly business customers. This fact implies that several parcels had to be delivered each day to specific addresses which is not so appropriate for cargo bikes because they need to return to the intermediate storage facility very often due to the limited load capacity. Hence, a densely populated area with above all private customers ordering usually just a few parcels seems to be more appropriate for implementing a cargo bike delivery (INNS'PAKET project, 2020).

5.3 Appropriate locations for midi hubs

A major challenge of implementing cargo bikes in urban delivery schemes is finding an appropriate location for intermediate storage. Depending on the size of these facilities, they are referred to as micro hubs (size of some hundred square metres) or midi hubs (size of some thousand square metres).

When planning to make the delivery of goods in a large city like Vienna more environmentally friendly, especially parcels could be transported by small emission-free vehicles in the inner-city area. To do this, midi hubs located around the city centre can serve as appropriate means to consolidate parcels for performing the last mile with cargo bikes or small electric vehicles. Due to the fact that in 2019 about 95 million parcels were delivered in Vienna, an increase of 9% compared to 2018 (WKO, 2020), and in addition to this continuous increase, the COVID-19-pandemic further contributes to growing parcel volumes, at least three such midi hubs were assumed to be required to handle the parcel volume in the wider city centre of Vienna.

The first step in finding appropriate locations for midi-hubs was to determine which locations are available. Hence, it needs to be answered, where sufficient free space within the city that can be used as midi hub can be found. After recherche and discussions with city representatives nine potential locations could be identified.

For the evaluation of the nine potential locations for midi hubs an Analytic Hierarchy Process (AHP) was applied. In the AHP quantitative as well as qualitative criteria can be used. Three main criteria were used: costs, environmental and social aspects, and

location-specific characteristics. Each main criterion was further subdivided and then a pairwise comparison of all sub-criteria regarding importance from different stakeholder perspectives was done. Companies, municipality representatives and citizens were asked. The latter group in a workshop, the others in an online survey.
After evaluating the relative importance of the sub-criteria to each other, indicators were defined for each sub-criterion to assess the relative performance of a specific location to all other locations. These results were weighted by using the matrix of relative importance of all criteria which finally results in a ranking of all potential midi hub locations for each stakeholder group (Anderluh et al., 2020).
A rough assessment of the impact of the best-ranked three midi hubs showed an emission reduction potential of up to 25% when delivering all parcels in the wider city centre area in Vienna either with cargo bikes or with small electric vehicles. This result holds even when the companies just use the infrastructure of the hub together but do not cooperate in the last mile delivery.

5.4 The benefits of bundling goods for delivery

As already pointed out in Section 5.3, online shopping is on the rise. During the COVID-19-pandemic, new customer segments, new industries and local shops were opened up on a large scale by connecting to online retail and hence contributing to e-commerce volumes. This leads especially under the current market conditions to a significant increase in the volume of goods traffic.
Although several innovative approaches have already been tested to improve the situation like initiatives for cross-company cooperation between logistics service providers to bundle freight flows, they have so far not been successful due to competition issues. Appeals to individual responsibility for the bundling of orders on the customer side also turn out to be ineffective. In addition, emission-free delivery services are only rarely offered by online shops.
Therefore, a promising option lies in the restructuring of the commissioning process for delivery services. The plan is to establish an independent online platform for the organization of logistics services. Hence, instead of placing decentralized delivery orders through individual dealers, deliveries are centrally coordinated and commissioned by the platform targeting on the interests of society as a whole.
This approach allows to optimize good flows even before the delivery itself by (1) bundling orders according to the spatial distribution of customers and dealers, (2) temporal aggregation of order requests or delivery time windows according to customer requirements and (3) offering sustainable, emission-free delivery services to all suitable customer addresses.
Overall, the spatial and temporal bundling of orders can result in a reduction in delivery frequency and an increase in vehicle utilization. In addition, the increased usage of emission-free small vehicles like cargo bikes for delivery actions can reduce emissions,

mitigate noise and congestion and can finally contribute to an improved quality of life in the city (BündelHeinz project, 2022).

5.5 Logistics concepts as part of Circular Economy

The Circular Economy Research Network of the European University E³UDRES² (Engaged and Entrepreneurial European University as Driver for European Smart and Sustainable Regions) is dedicated to developing and evaluating innovative logistics concepts together with citizens and stakeholders, facilitating the use of cargo bikes, in different European countries. Using cargo bikes for appropriate deliveries in city areas can contribute to emission reduction as well as to increased liveability in cities. Transport resources and capacities can be efficiently used and exploited, thus leading to a decrease in motorized freight traffic.

Novel concepts and approaches in sustainable mobility and in resource efficiency are developed and evaluated. For these concepts economic, ecological and social objectives representing the conflicting perspectives of diverse actors are included. At the same time, new behavioural approaches are proposed instead of solely focusing on technological development. The factors affecting consumer behaviour in the context of the circular economy are economic factors, the fit between needs and offering, information, social factors, and individual consumer preferences (European Environment Agency, 2022). Municipalities, citizens, and private sector companies are connected and supported in how they can achieve the transition towards a circular economy in their region and in their daily life.

The Circular Economy Research Network aims at increasing the understanding of the interdependence between the supply / use of (limited) resources and the fulfilment of demand in urban areas, through better understanding and knowledge of stakeholders' requirements and limitations to facilitate the transformation process from a linear urban economy to a closed-loop sustainable economic system. Decision makers are supported in implementing urban circular economic systems, tailored to the societal challenges of particular regions. Innovative logistics concepts and urban delivery processes performed with cargo bikes are designed to lead to a more socially balanced co-existence in an urban environment. The concepts are developed generically in order to enable their transfer, so that they can be shaped to the specific requirements of individual and diverse regions (E³UDRES² project, 2021).

6 Conclusion

Growing urbanization as well as the challenges to reduce climate change increase the necessity of improving delivery processes in urban areas. A promising idea is the integration of small environmentally friendly vehicles like cargo bikes in urban delivery schemes. These vehicles benefit from flexibility, zero-emission and noiselessness but on the other hand are limited in loading capacity and operating range. Hence, the

implementation of such vehicles needs to be thoroughly planned and accompanied by appropriate additional measures and actions.
The results of a number of national and international research projects – some of which are still on-going, point out the potential of cargo bikes as an excellent substitute for, as well as combination with, conventional delivery vehicles in inner-city areas when considering parcel-sized deliveries. Prerequisites for a successful implementation are (1) the commitment of the company to using such delivery vehicles, (2) an additional support by the municipality by setting appropriate conditions and (3) an appropriate integration of cargo bikes in the company's urban delivery scheme by means of suitable vehicle routing algorithms, which consider for example the usage of mixed fleets, synchronization between vehicles to transfer goods or intermediate storage of goods at differently sized hubs. Hence, the challenges of cargo bikes need to be considered in the implementation phase.
The benefits of using cargo bikes in urban delivery can be seen in the reduction of emissions (carbon dioxide, nitrogen oxides and particulate matters) and noise as well as in the reduced number of conventional vehicles required especially in city centers which contributes to less congestion. Hence, the positive impact concerns the climate as well as the wellbeing of citizens and in the long run also the economy.

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References

Anderluh, A., Hemmelmayr, V.C., Nolz, P.C., 2017. Synchronizing vans and cargo bikes in a city distribution network. Cent Eur J Oper Res 25, 345–376. https://doi.org/10/gh38bn

Anderluh, A., Hemmelmayr, V.C., Rüdiger, D., 2020. Analytic hierarchy process for city hub location selection - The Viennese case. Transportation Research Procedia 46, 77–84. https://doi.org/10.1016/j.trpro.2020.03.166

Anderluh, A., Hemmelmayr, V.C., Wakolbinger, T., 2016. Einsatz von Lastenfahrrädern zur innerstädtischen Güterlieferung – ein Städtevergleich und Best Practice Empfehlungen für die Stadt Wien (Final Report). WU Jubiläumsfond der Stadt Wien, Wien.

Arnold, F., Cardenas, I., Sörensen, K., Dewulf, W., 2018. Simulation of B2C e-commerce distribution in Antwerp using cargo bikes and delivery points. Eur. Transp. Res. Rev. 10, 1–13. https://doi.org/10.1007/s12544-017-0272-6

Assmann, T., Lang, S., Müller, F., Schenk, M., 2020. Impact Assessment Model for the Implementation of Cargo Bike Transshipment Points in Urban Districts. Sustainability 12, 4082. https://doi.org/10.3390/su12104082

Boysen, N., Fedtke, S., Schwerdfeger, S., 2021. Last-mile delivery concepts: a survey from an operational research perspective. OR Spectrum 43, 1–58. https://doi.org/10.1007/s00291-020-00607-8

Browne, M., Allen, J., Leonardi, J., 2011. Evaluating the use of an urban consolidation centre and electric vehicles in central London. IATSS Research 35, 1–6. https://doi.org/10.1016/j.iatssr.2011.06.002

BündelHeinz project, 2022. BündelHeinz - Neuartiger Lösungsansatz zur unabhängigen Bündelung und Ökologisierung von Bestell- und Lieferprozessen [WWW Document]. URL https://research.fhstp.ac.at/projekte/buendelheinz-neuartiger-loesungsansatz-zur-unabhaengigen-buendelung-und-oekologisierung-von-bestell-und-lieferprozessen (accessed 6.13.22).

Dybdalen, Å., Ryeng, E.O., 2021. Understanding how to ensure efficient operation of cargo bikes on winter roads. Research in Transportation Business & Management 100652. https://doi.org/10.1016/j.rtbm.2021.100652

E^{3}UDRES^2 project, 2021. E^{3}UDRES^2 - ENGAGED AND ENTREPRENEURIAL EUROPEAN UNIVERSITY AS DRIVER FOR EUROPEAN SMART AND SUSTAINABLE REGIONS [WWW Document]. URL https://eudres.eu/ (accessed 6.13.22).

Enthoven, D.L.J.U., Jargalsaikhan, B., Roodbergen, K.J., uit het Broek, M.A.J., Schrotenboer, A.H., 2020. The two-echelon vehicle routing problem with covering options: City logistics with cargo bikes and parcel lockers. Computers & Operations Research 118, 104919. https://doi.org/10.1016/j.cor.2020.104919

European Commission, Gronkiewicz-Waltz, H., Larsson, A., Boni, A.L., Krogh Andersen, K., Ferrao, P., Forest, E., Jordan, R., Lenz, B., Lumbreras, J., Nicolaides, C., Reiter, J., Russ, M., Sulling, A., Termont, D., Vassilakou, M., 2020. 100 climate-neutral cities by 2030 - by and for the citizens: report of the Mission board for climate neutral and smart cities. Publications Office of the European Union, LU.

European Environment Agency, 2022. Enabling consumer choices for a circular economy [WWW Document]. URL https://www.eea.europa.eu/publications/influencing-consumer-choices-towards-circularity/enabling-consumer-choices-towards-a (accessed 6.13.22).

European Parliament, 2015. Kreislaufwirtschaft: Definition und Vorteile [WWW Document]. URL https://www.europarl.europa.eu/news/de/headlines/economy/20151201STO05603/kreislaufwirtschaft-definition-und-vorteile (accessed 6.13.22).

European Union, 2020. EU Transport in Figures: Statistical Pocketbook 2020. Publications Office of the European Union, Luxembourg.

Gruber, J., Kihm, A., Lenz, B., 2014. A new vehicle for urban freight? An ex-ante evaluation of electric cargo bikes in courier services. Research in Transportation Business & Management, Managing Freight in Urban Areas 11, 53–62. https://doi.org/10.1016/j.rtbm.2014.03.004

INNS'PAKET project, 2020. INNS'PAKET - Koordinierte und kooperative Zustellung von Paketen und Kleinsendungen im Großraum Innsbruck [WWW Document]. URL https://research.fhstp.ac.at/projekte/inns-paket (accessed 6.13.22).

KoopHubs project, 2018. KoopHubs - Konzeption eines nachhaltigen, kooperativen, zweistufigen Distributionssystems für Kleinsendungen in der Stadt Wien.

Mayring, P., 2010. Qualitative Inhaltsanalyse. Grundlagen und Techniken. Beltz.

Nolz, P.C., Absi, N., Cattaruzza, D., Feillet, D., 2020. Two-echelon distribution with a single capacitated city hub. EURO Journal on Transportation and Logistics 9, 100015. https://doi.org/10.1016/j.ejtl.2020.100015

Seel, M., Heller, M., Anderluh, A., 2022. EFFECTS: Gesundheitliche Bewertung aktiver Mobilität. ÖGPH-Newsletter 11–13.

Szmigiera, M., 2021. Urbanization by continent 2021 [WWW Document]. Statista. URL https://www.statista.com/statistics/270860/urbanization-by-continent/ (accessed 5.30.22).

Vasiutina, H., Szarata, A., Rybicki, S., 2021. Evaluating the Environmental Impact of Using Cargo Bikes in Cities: A Comprehensive Review of Existing Approaches. Energies 14, 6462. https://doi.org/10.3390/en14206462

WKO, 2020. KEP Branchenreport 2020 Wien. WKO, Vienna.

Cookstove Energy Sector: Arenas in Transitions to Accessible and Affordable in Global South

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Abstract. According to the World Health Organization (WHO, 2014), around 3 billion people still cook using solid fuels (such as wood, crop wastes, charcoal, coal, and dung) and kerosene in open fires and inefficient stoves. Most of these people are poor and live in global south countries. Clean cookstoves are easy to handle but are not easily accepted by the communities. Sustainability transitions are necessary to promote changes in communities in poor regions to become more sustainable and healthier, especially in this cookstove energy industry that promotes transitions towards a low carbon future and involves multiple actors. When analysing the conditions and processes of transitions, the arenas of development (AoD) approach provides an alternative framework in the context of sustainability transitions in the cookstove energy sector. Though the problem has been investigated, how can actors and locations engaged promote sustainability transitions in the cookstove energy sector? Our research aims to characterize how actors' and locations' engagement promotes sustainability transitions in the cookstove energy sector. Based on the proposition for transformative social innovation (TSI) of Pel et al. (2020), this research will bring social innovation to the involved communities to create more sustainable and healthier conditions than the prior situation.

Keywords: Energy Transitions, Transformative Social Innovation, Arenas of Development, Actors

1 Introduction

Around 3 billion people (low- and middle-income countries) still cook using solid fuels (such as wood, crop wastes, charcoal, coal, and dung) and kerosene in open fires and inefficient stoves (Boudewijns et al., 2022; Hooper et al., 2018; WHO, 2014). These cooking practices are ineffective and use fuels and technologies that produce high levels of household air pollution with many health-damaging pollutants, including small soot particles that penetrate deep into the lungs. Exposure is exceptionally high among women and young children, who spend most of their time near the domestic hearth. The situation resembles decades ago when the communities were cooking with pollutants and inefficient stoves. Now, we have technologies to mitigate this scenario. Even research reinforces this context of the able transition to clean cooking. Therefore, it is important to understand the problem. Indoor air pollution kills more people than tuberculosis, AIDS, and malaria together (Aemro et al., 2021). In other words, it is the same as putting a car in a room and working or making anything with this smoke.

These practices are changing because many policies, projects, and public and private institutions work to mitigate this situation. Furthermore, Sustainable development goal 7 of the United Nations highlights the social, public health, and environmental benefits of the transition to clean cookstoves (Maji & Kandlikar, 2020; Pachauri et al., 2021).

Sustainability transitions are necessary to promote changes in communities localized in poor regions. To make these communities more sustainable, we need to enable solutions like the cookstove energy industry that promote transitions toward a low-carbon future and involve multiple actors. Unfortunately, the energy transition is hampered by several factors: caste, socio-political position, a heritage structure, remoteness, culture, and access to technology (Goswami et al., 2017; Menghwani et al., 2019). However, rapid advances in technologies could facilitate the transition. For this reason, cultures need to be changed to achieve energy transition goals (Sovacool & Griffiths, 2020).

When analysing the conditions for and processes of transitions, the arenas of development (AoD) approach provides an alternative framework in the context of sustainability transitions in the cookstove energy sector. Based on this context, our research question is how can actors and locations engaged promote sustainability transitions in the cookstove energy sector? It aims to characterize how actors' and locations' engagement promote sustainability transitions in the cookstove energy sector. To attain this research aim, we adopt arenas of development as our framework (Jørgensen & Sørensen, 1999). The framework focuses on agency in a cognitive space that holds together the settings and relations that comprise the context for a product or process development, and the analysis of innovation and interactions from multiple points of view, corresponding to the different visions of other groups of actors involved in a particular arena (Sillig, 2022). Besides, the study of arenas of development (AoD) may contribute to understanding transitions in the cookstove energy sector and provide a background of information about how different actors can navigate and perform strategic interventions that support sustainable transitions.

In the following sections, this research introduces the energy transitions in the cookstove, the cleaner cookstoves, transformative social innovation, and the AoD approach and their theoretical foundations and assumptions. In the next section, the methodology is described. After that, an empirical case study of actor-networks involved in the cookstove energy sector in the arena of development of the global south is prescribed. Finally, the article concludes with a discussion of the findings of this research.

2 Theoretical framework

2.1 Energy transitions in the cookstove

Sustainability transitions are understood as multi-level, multi-phase processes of structural change in social systems. They are realized when the dominant social structures (regimes) come under pressure from external societal changes and endogenous innovations (Loorbach, 2010; Koop & van Leeuwen, 2017). Sustainability transitions research focuses on significant transformations in the established sectors such as energy, food, transport, or mobility associated with and triggered by sustainability challenges and has expanded, diversified, and deepened since 2010 (Markard, 2017; Sharp & Salter, 2017; Sovacool et al., 2020).

When we talk about the inequality of means between the Global North and the Global South, it has cost way too many lives so far. Moreover, if that was not enough, when the response has been overly slow or insufficient, the socioeconomic impacts of the COVID-19 pandemic have been much more acute than necessary, pushing many more into deeper poverty and so jeopardizing the prospects of future generations ("The Cost of Inequality," 2022). Indeed, the energy transition decelerated, too, in poor communities. However, Goswami et al. (2017) affirm that bringing clean energy again to enable a rural energy transition in developing countries needs to provide clean energy for bare subsistence, such as cooking and lighting. The same authors say it is also about access to services provided through the energy grid.

The energy transition in countries of the global south is hampered by several factors, such as caste, socio-political position, a heritage structure, remoteness, culture, and access to technology (Goswami et al., 2017). In addition, despite incentives, the transition by local, regional, and international actors depends on several factors, such as education, wealth, caste, family size, gender responsibilities, and others (Menghwani et al., 2019). However, transitions are facilitated by rapid technological advances; cultures need to be changed to achieve energy transition goals (Sovacool et al., 2020). Furthermore, regardless of technology options, implementation strategy choices, or geographic contexts, a successful transition at the domestic level essentially involves taking new behaviours into action (Kar & Zerriffi, 2018).

In sum, removing access to modern fuel in an economically and spatially stratified society is a highly negotiated and contested process. An example is the use of Liquefied Petroleum Gas that continues to be limited by structural conditions, especially existing infrastructure. In addition, a transition is made difficult by the rooted culture (Wang & Bailis, 2015). Another study stated that the current interventions promoted by the Promotion Program are insufficient to promote the sustainable use of other kinds of energy, such as cookstoves (Carrión et al., 2021).

2.2 Cleaner Cookstoves

Sustainable development goals (SDGs) have been stated as a global priority. The discussion on just and sustainable energy transitions and the clean cooking fuel that defines the end of poverty and inequality, energy for all, good health and well-being, gender equality, and sustainable growth to protect the environment, among others (Schilmann et al., 2021; Ravindra et al., 2021). The transition process has been framed in the cookstove literature as a technology-centric issue about the identification of a multitude of factors that encourage or discourage technology acquisition/uptake (purchase or acceptance) and technology usage of traditional cookstoves to Improve cookstoves (Goswami et al., 2017; Kar & Zerriffi, 2018). Furthermore, other studies have focused on understanding the determinants of adoption and on the sustainable use of improved and cleaned cookstoves (Carrión et al., 2020).

Improve cookstoves technology is characterized by improving fuel combustion efficiency and reducing household air pollution by redesigning the simple biomass fuel-burning cookstoves (Hooper et al., 2018). These improved or cleaner cookstoves are advancing as instrumental in expanding access to modern energy services (Sovacool & Griffiths, 2020) through a shift to clean, efficient cooking energy from inefficient ones with a rise in the income ladder is not unidirectional (Goswami et al., 2017). For this reason, a clean cooking energy transition necessitates effortful behaviour changes by cookers, financial decision-makers, and other family members (Kar & Zerriffi, 2018).

Despite continual efforts, the likelihood of a rapid transition to cleaner cooking fuels is low (Menghwani et al., 2019). The recent COVID-19 lockdowns have impacted the transition towards clean cooking fuels. In many countries, especially in the global south, the lockdown affected households' ability to access essential needs. On the one hand, this was accentuated in rural and remote areas already struggling to access clean fuels (Ravindra et al., 2021). On the other hand, evidence worldwide indicates that very seldom, particularly in rural areas, are clean fuels such as liquefied petroleum gas (LPG) used exclusively, which also faces problems reaching the poorest and more remote households (Serrano-Medrano et al., 2018). Moreover, there is a research and policy gap regarding the commercialization of clean cooking technologies, consumer preferences between Ghana-made stoves and imported ones, and the evaluation of locally made ones (Ackah et al., 2021).

Therefore, conventional energy transition models emphasize households' socioeconomic improvement as the most critical driver of the energy transition. However, a clearer understanding of various factors determining stove ownership and selection gives breadth to our conception of energy transition globally (Wang & Bailis, 2015). For this reason, renewed efforts are needed to ensure a sustainable and just household energy transition in the global south (Schilmann et al., 2021).

According to previous studies (Wiedinmyer et al., 2017; Medina et al., 2019; Mazzone et al., 2021), it is essential to bring cultural practices and cooking traditions because specific cooking methods are the main barriers to increasing adoption rates of improved cooking technologies (Fingleton-Smith, 2022). Additionally, the need to know which factors cause people to decrease or stop using their clean cookstoves (Carrión et al., 2020). Furthermore, women play a significant role in changing these social practices by using clean cookstoves (Dickinson et al., 2019; Jewitt et al., 2022; Menghwani et al., 2019). Therefore, it can save millions of lives a year, especially among women and children suffering from indoor air pollution, especially in the global south (Sovacool & Griffiths, 2020).

Another factor is that the energy must not be only accessible but affordable. However, the use of firewood for cooking or other uses is still more economical than other fuels (Mazzone et al., 2021). The same authors affirm that the supply of LPG in remote communities in the global south is particularly challenging because of its geography and the cost related to transportation (Mazzone et al., 2021).

Governments and civil society in the global south, along with international actors, promote both transition technologies that make solid fuels burn in a cleaner manner, such as "improved" cookstoves (ICS) as well as truly clean cooking solutions (CCS)- modern fuels, such as LPG, electricity, biogas, and ethanol, that critically contributes to human and economic development (Wang & Bailis, 2015; Kar & Zerriffi, 2018). However, efforts have not been entirely successful regarding the financial resources and the program's effectiveness (Schilmann et al., 2021).

Recently, researchers have proposed a solid-fuel suspension framework to understand the determinants of transitioning to exclusive clean fuel use (Carrión et al., 2020). Indeed, future scenarios have been developed that examine the GHG mitigation impacts of alternative ICS dissemination interventions. However, most of these efforts lack a spatial component. Their outcomes are presented in terms of aggregated national or regional data (Serrano-Medrano et al., 2018).

2.3 Transformative social innovation

The theme of social innovation has been widely studied by different areas of knowledge in recent years. This debate brings essential concepts regarding sociotechnical transition, such as innovative social transformation, which is understood as a process that encompasses different actors and results in the alteration or replacement of dominant institutions or organizations in a social context. Unlike Social Innovation (SI), which is related to "the fact that people do things differently due to this innovation, alone or together" (Franz et al., 2012, p. 5). Transformative Social Innovation (TSI) goes beyond changes in social practices. It challenges, alters, or replaces dominant institutions in the social context (Haxeltine et al., 2016), provoking a much deeper change.

It is a social innovation capable of transforming the scenario irreversibly from its perspective, values, and behaviours (Avelino et al., 2019). Therefore, we can characterize this process as co-evolutionary, as it interacts with other social innovations and changes, affecting its transformative potential and enhancing its scale of impact. These changes will affect the social context in which they are inserted and result in profound impacts on society.

Furthermore, this process is divided and shared through "webs" or "networks" of social and material relationships (Pel et al., 2020) between different groups of people, institutions, companies, and actors in general, that contribute to its development. Additionally, from the arenas of development perspective, it results in a significant change in the actors that are part of the arena where this process takes place and consequently in the limits in which this arena develops.

2.4 Arenas of development

The arenas of development (AoD) theory enables an analysis of the cookstoves energy sector, the importance of the transition to clean cookstoves changing visions, and new practices in several global south countries. It is an alternative approach to transition analysis and is inspired by actor-network theory (Jørgensen & Sørensen, 1999; Jørgensen, 2012; Jørgensen et al., 2017; Heiskanen et al., 2018; Sillig, 2022). According to Jørgensen & Sørensen (1999), the arena is a cognitive space that holds together the settings and relations that comprise the context for a process that includes several elements such as actors, artifacts, and standards that populate the arena. Thus, action locations that generate knowledge and prospects change in this space. Furthermore, a set of translations have shaped and played out the stabilization and destabilization of relations and artifacts. Since the AoD objects of analysis are transitions (Valderrama Pineda & Jørgensen, 2016), it emphasizes its integrated socio-material relations. It responds to the need for an improved theory of transition processes that understand actors' navigations and performances(Jørgensen, 2012).

An actor-world is developed around a certain set of situations and is thereby limited to what we here call a location in the space of a development arena (Jørgensen & Sørensen, 1999). Therefore, involved actors view them as broad social and technological transformations. These transformations could change the fundamental constitution of our communities in the global south (Jørgensen, 2012; Valderrama Pineda & Jørgensen, 2016). In the perspective of arena framing actors' intervention, conflicting matters of concern are instrumental in setting the stage and framing the policy processes within an arena and the different choices of strategy and instruments that support the changes in institutions and technologies (Jørgensen et al., 2017). Thus, the AoD perspective is deemed particularly relevant in the cookstove energy sector when alternative practices and conflicting views and visions emerge that lead to controversies and dialogues among the actors and are open to changes in the sociotechnical configuration (Heiskanen et al., 2018).

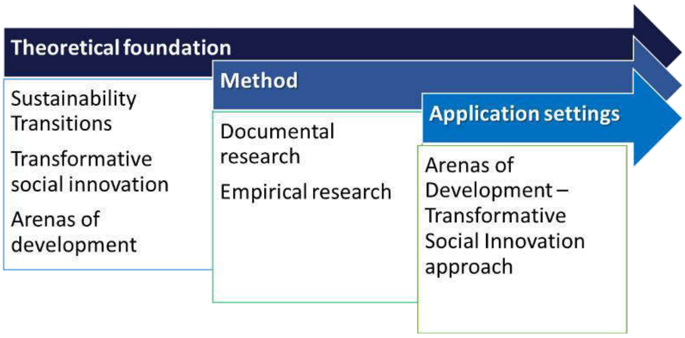
Societies are composed of different changing arenas of development that can oppose, or complement, or interact, or overlap in different and contradictory ways (Valderrama Pineda & Jørgensen, 2016). The AoD approach to studying transitions applied in this article cultivates sensitivity toward actors' engagement in the creation, operation, and governance of sociotechnical systems (Jørgensen et al., 2017). Furthermore, the approach offers a scalable tool for detailed studies of changes in sociotechnical systems as well as broader cross-sector and international changes, which are in the cookstove energy sector (Jørgensen et al., 2017; Sillig, 2022).

In sum, the AoD approach first focuses on actor-network theory. Also, their change dynamics are tensions between actor-worlds resulting in changing alignments and boundaries. Moreover, their core framing configuration is actor-worlds that emphasize their frames of interpretation and conflicting perspectives. In fact, the role of actors as navigators, performing visions and socio-material practices. Furthermore, this approach included the researcher's position as another actor, though privileged. Finally, the researcher's challenge is to search for boundaries and stabilizing configurations.

3 Methodology approach

The methodologic approach involves three stages as follows. First, it will be characterized by the theoretical foundation of energy transitions in the cookstove, cleaner cookstoves, and the arenas of development (AoD) approach. Secondly, based on the documental research, we analyse the actors involved in the cookstoves energy sector. And finally, the founding principles and organization logic evidenced in the document collection related to the AoD approach for this research will be characterized, as shown in figure 1.

Figure 1 – Methodological Scheme



Source: Authors, 2022

Documental research may include "any written and non-written record which exists and may enhance the researcher's overall understanding of the situation under study" (Gay et al., 1996. p. 221). The documents identified come from several actors that help to transform the cookstove energy sector, such as Biolite, Doña Dora, USAID, and Clean Cooking Alliance were selected based on the previous relationship with the researcher. Additionally, the agenda 2030 of sustainable development goals 3, 4, 5, 7, and 13.

- Biolite is a social enterprise in New York that develops, manufactures, and distributes advanced clean energy technologies to off-grid households worldwide (https://global.bioliteenergy.com/, accessed: 21/04/2022).

- *Estufas Doña Dora* is another social enterprise located in Quetzaltenango, Guatemala, that sells customized stoves to Guatemalan families who depend on firewood as a source of energy for cooking.
- The United States Agency for International Development (USAID) is an international cooperation agency for administering civilian foreign aid and development assistance. USAID developed cookstove programs have the potential to improve the health, livelihoods, and environment of the three billion people who still rely on traditional stoves and solid fuels to feed their families (https://www.usaid.gov/energy/cookstoves, accessed: 21/04/2022).
- The Clean Cooking Alliance is a multilateral organization with the support of the United Nations Foundation to promote clean cooking technologies in lower and middle-income countries. Its mission is to work with a global network of partners to build an inclusive industry that can make clean cooking accessible to all (https://cleancooking.org/mission-impact/, accessed: 21/04/2022).

The documents analysed in this research were:

- Biolite Environmental Sustainability Report (2018). This report represents a potential mechanism to generate data and measure progress and the contribution of social enterprises toward global sustainable development objectives.
- Biolite 2018 Impact report: An article on an organization's accurate demonstration of the impact of an investment or program.
- Executive Summary Biolite: Overview document of the Social enterprise.
- Clean and efficient cooking technologies and fuels, USAID, 2017: The toolkit provides an overview of how the cookstove sector is evolving, best practices, and key challenges.
- *Alianza Global para Estufas Limpias*, Global Alliance for Clean Cookstoves, 2013: *Análisis del Mercado de Estufas y Combustibles de Guatemala.*
- *Estufas mejoradas de leña en Centroamerica: Detonando mercados, 2013*: Report of market of cookstoves in central America
- *I Seminario Taller Latinoamericano De Cocinas / Estufas Limpias,* Global Alliance for Clean Cookstoves, 2014: Report of Latin American Workshop on Clean Cooking: Promoting Adoption and Sustained Use at Scale.
- Agenda 2030: Sustainable development goals: 3 – Good Health and Well-Being; 4 – Quality education; 5 – Gender Equality; 7 – Clean and Affordable Energy; 13 – Action Against Global Climate Change.

To analyse these documents, we applied the AoD steps presented below (Jørgensen, 2012).

- Define the scenario to be analysed. We were starting from the point where we understand AoD as spaces where we can organize processes and interactions between different actors. The first step is to identify the arena, where we will look, what will be the theme in focus during the analysis, and start the other identifications based on that.

- Identify the main actors involved; after identifying the scenario, we analyse the key actors who represent the arena, such as markets, academia, and third sector, culture, technology, policy, and industry.
- Check which connections exist between the actors. It is important to understand the connections to analyse the influences in the environment in which they are inserted. AoD uses the idea of partial connections and multiple stories. Therefore, the actors' connections are fundamental to understanding how the arena behaves.
- Understand how the actors' performance influences the stabilization and definition of arena boundaries. At the beginning of the approach, the constellations of actors were identified, and their interactions and collective creative activities were perceived, which will define the limits of AoD, that is, how far it extends. AoD will go no further than the performance and collective interactions of actors allow. Therefore, understand the possibilities of AoD due to the constant changes between the actors and their performances. Additionally, the boundaries of the arena are constantly changing.
- Identify the heterogeneous sets of entities within the arenas that form the actors-network. The actors-network comprises a heterogeneous set of entities within an arena, including humans, technologies, institutions, visions, and practices endowed with their specific meaning, position, and identity through their interconnection in network relationships. They are, therefore, entities that within an Arena are organized and stabilized through their interconnections.
- Identify which actors-world are generated from the structuring and stabilization of actors-network. From the previous stage, where the actors-network is organized and stabilized, the actors-world appears. They are semiotic networks that produce in parallel the focus, limits, and dynamics of the arenas through the relationships and internal tensions created between them and the actors' performance that constitute the actor-network frontier.
- Monitor the tensions and misalignments within the actor-world and the ongoing restructuring and readjustment processes generated. The importance of monitoring tensions and misalignments in the actors-world starts from the idea that these aspects, within an actor-world, result in continuous processes of restructuring and readjustments. The spatial dimension of the arenas provides an analytical view of these crucial dynamics for the transformations that re-signify and reshape socio-material relationships. It is worth mentioning that actors can have multiple identities and commitments. Therefore, they can be enrolled in more than one actor-world set simultaneously.
- Analyse changes in arena boundaries based on actors' performances. The arenas are restructured, and their limits can expand or shrink depending on the actor's performances when trying to stabilize, transform or even destabilize the actor-worlds

in the arena. The performance dimension focuses on discursive, organizational, or material events. What counts as performance are, therefore, different types of practices that operate through interactions, demonstrations, and other ways of creating a presence concerning other actors, comprising a variety of acts that range from visions and narratives of meaning to materialized interventions.

- Describe the policies and interventions of actors in innovation processes for a better understanding based on the analyses carried out. From the analyses developed, describe which policies and interventions of the actors had effects on innovation processes, thus highlighting their relevance within the concepts of social innovation.

4 Results

The starting point of this research emerged from analysing a macro scenario, considering sustainable transition initiatives that aim for clean cookstoves, from the perspective of AoD. First, we identified the actors-world that works in this area. Then, by reading the documents and material available on their website, we analysed their performance contrasting with the SDGs as parameters, with the specialized literature, and from reports investigated. This analysis validated the low-income communities, local government, social enterprises, multilateral agencies, international cooperation agencies, and the research as actors within the cookstove sector arena. Furthermore, the actions carried out by these actors moved the scenario, reaching other actors that happened to be new actors who are part of this transition process. The data analysis is summarised in table 1.

Table 1 - Approach to AoD in the cookstove energy sector

Define the scenario to be analysed	**The cookstove energy sector in global south countries**
Identify the main actors involved	Low-income communities Social entrepreneur (Biolite and *Estufas Doña Dora*) Local government Multilateral agency (Clean Cooking Alliance) International cooperation agency (USAID) Research institution
Check which connections exist between the actors	see fig 7
Understand how the actors' performance influences the stabilization and definition of arena boundaries	see fig 7
Identify the heterogeneous sets of entities within the arenas that form the actors-network	Clean cooking alliance - USAID Clean cooking alliance - USAID - Biolite Clean cooking alliance - USAID - Doña Dora Researcher - Biolite - Doña Dora
Identify which actors-world are generated from the structuring and stabilization of actors-network	see fig 7

Monitor the tensions and misalignments within the actors-world and the ongoing restructuring and readjustment processes generated	see fig 7
Analyse changes in arena boundaries based on actors' performances	Low-income communities: Buying, promoting, and using the clean cook stove. Financial institutions: Microloans to buy the cooking stoves. Local government: Policies to regulate the microloans and promote better health conditions. Social entrepreneur: Develop new products, sustainable practices, and social innovation. Multilateral agencies: Agenda setting, promoting SDGs, reports. International cooperation agency: Economic and technical cooperation, official development aid. Research institutions: Democratize knowledge and knowledge production.
Describe the policies and interventions of actors in innovation processes for a better understanding, based on the analyses carried out	Provide policies that generate health benefits relative to polluting options. Promote important incremental steps towards to cleaner option. It can help achieve interim air quality targets on the path toward reaching guideline levels.

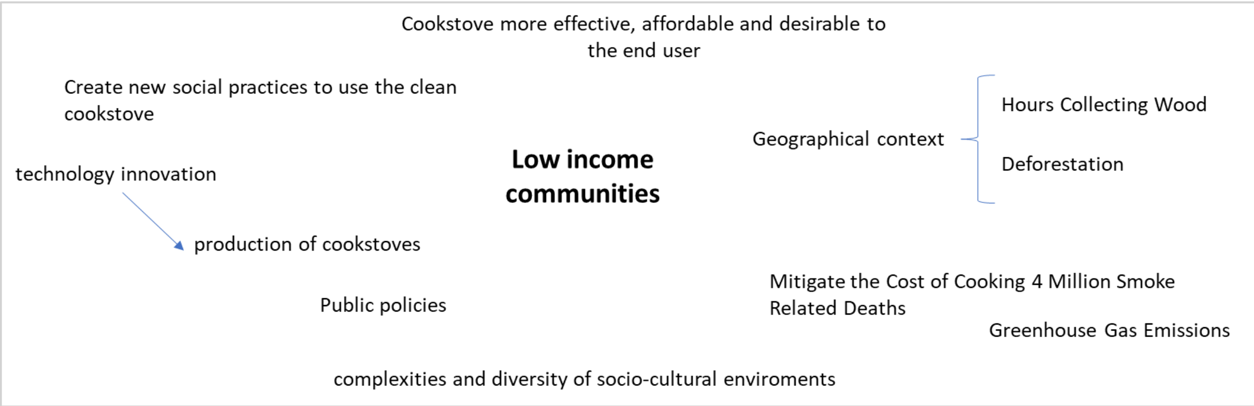
Source: Authors, 2012

The interaction between energy and poverty has been identified as critical to achieving a sustainable energy transition in global south countries. Indeed, several impacts in low-income communities exist. First, no effective public policies contribute to designing and planning long-term policies, programs, and incentives in the energy, environmental, forestry, and educational areas. Besides, there is no information platform and the generation of knowledge of successful experiences to be replicated in these local contexts. Furthermore, the cost of clean cookstoves, mass production, and commercialization is difficult since they cannot generate economies of scale.

Additionally, the geographical location in distant rural areas and the complex and diverse socio-cultural environments make implementing this type of stove challenging. Despite this, reducing the negative impacts on users' health is key to the energy transition. Exposure to smoke, the low efficiency of traditional stoves, particularly in infants and women (Sovacool & Griffiths, 2020), includes acute respiratory infections caused by inhalation of accumulated smoke in homes, burns, arthritis, and muscle pain. That means extraordinary expenses in the limited family income due to medical care and medicines.

The capacity to assess the energy-efficient profile of the cookstoves because the demand and its dynamics are complex due to factors such as cultural diversity, the customs of cooking food, availability of construction materials at the local level, and limited technical capacity to ensure adequate construction quality, lack of maintenance, among other aspects. Finally, the massive use of firewood causes an increase in the deforestation of protected natural forests. In addition, the absence of community programs to replace forest resources is evident, as shown in figure 2.

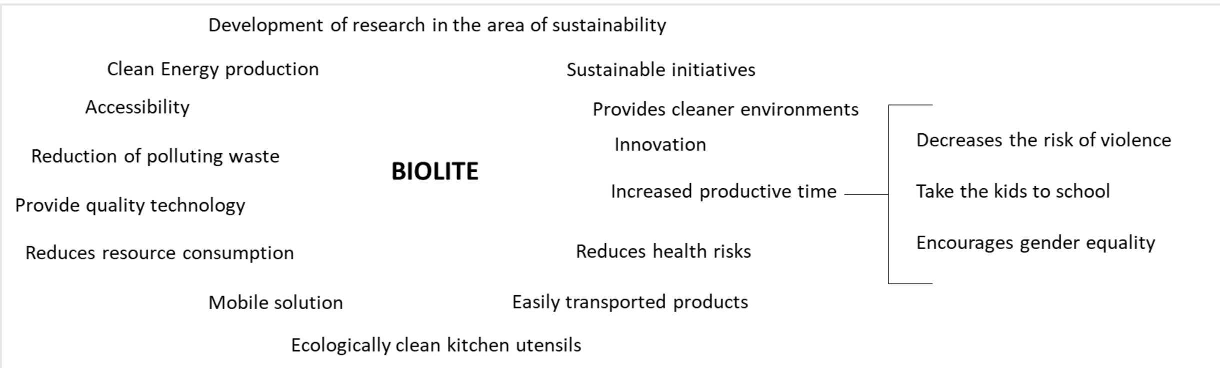
Figure 2 – Impacts/Performance Low-income communities



Source: Authors, 2022

The developed technology by Biolite considerably reduces the production of pollutants that helps mitigate the impacts of climate change. It also has an impact on the health and well-being of cookers as well as a social action that promotes gender equity if we start from the idea that women will no longer have as much work to cook, which will allow them to develop other activities. Likewise, it reduces the work previously carried out by children (of fetching fuel for cooking), allowing them to concentrate on their studies. Further, we can frame this social enterprise from SDGs 3, 4, 5, and 13, as shown in figure 3.

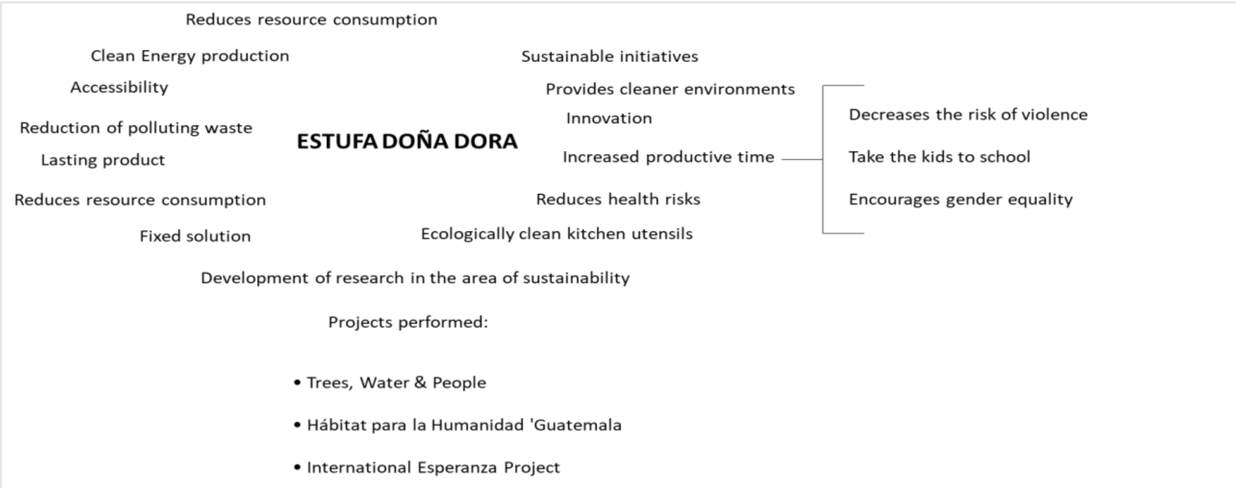
Figure 3 – Impacts/Performance Biolite



Source: Authors, 2022

Estufas Doña Dora is another social enterprise that operates in this sector, specifically in Quetzaltenango, Guatemala. Furthermore, we come from the same principles we used to analyse Biolite to consider as an actor in this arena. All information was also found on its website and supported evidence. Although, the low technology developed by Estufa Doña Dora is different from that developed by Biolite. They have similar impacts, and in this way, we can associate this social enterprise with SDGs 3, 4, 5, and 13, as shown in figure 4.

Figure 4 – Impacts/Performance Estufas Doña Dora

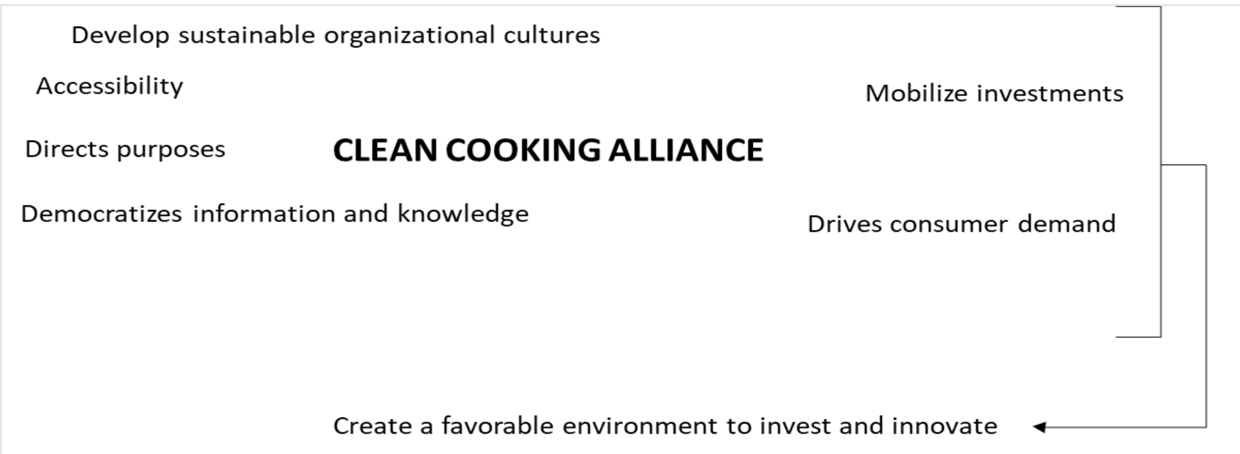


Source: Authors, 2022

As we were trying to understand some of the main actors and their roles, we found the Clean Cooking Alliance, which has a very important role due to its ability to fundraise and democratize knowledge about clean kitchens. We relate it to the SDGs based on its functions within the global scenario, as it is responsible for raising awareness of companies and people about the sustainable and social problems generated in an old-fashioned kitchen which can be linked to SDGs 3, 4, 5, 7, and 13.

The Clean Cooking Alliance also relates to all other actors, as it is one of the main references in relation to the cookstoves. Due to these issues, it is an important player that expands the horizons of this development arena, as shown in figure 5.

Figure 5 – Impacts/Performance Clean Cooking Alliance

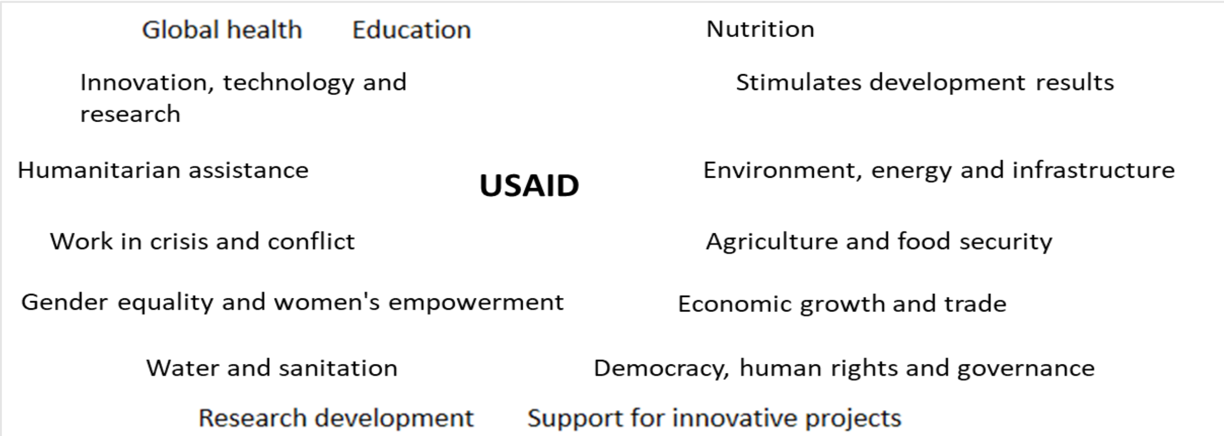


Source: Authors, 2022

Another actor is USAID which supports projects in various areas of the SDGs, including working with projects in the sector of clean cookstoves. Furthermore, we consider USAID as one of the actors which supports the 2030 agenda in other projects related to inequality reduction. Besides, the agency provides financial support due to its size and number of resources and has the potential to make a difference in this scenario.

Therefore, due to its nature, we believe it can become one of BioLite's stakeholders, promoting its transformative and sustainable projects, as shown in figure 6.

Figure 6 - Impacts/Performance USAID

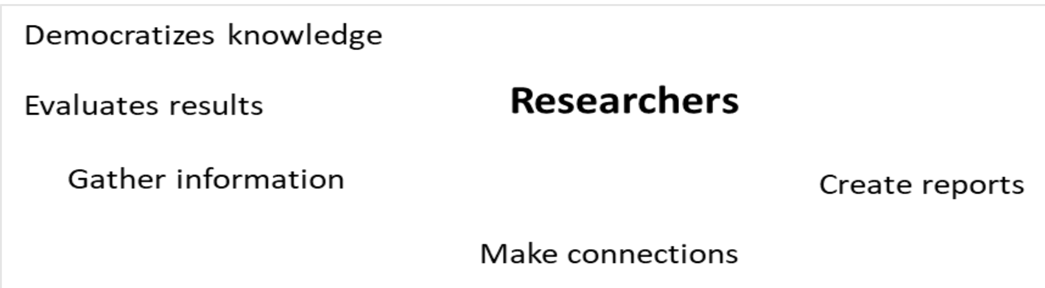


Source: Authors, 2022

The SDGs 3 – Good Health and Well-Being; 4 – Quality education; 5 – Gender Equality; 7 – Clean and Affordable Energy; and 13 – Action Against Global Climate Change are the basis that guides the research parameters, together with the AoD perspective. Through them, we can categorize and validate the initiatives developed by the other actors. Therefore, AoD has a fundamental role, along with the other actors. Also, it helps to expand the limits of the arena in the cookstove energy sector. Furthermore, Because of its role and what it represents, all other actors related to it, even if indirectly, play a central role in our research.

Finally, the researchers, despite not being directly linked to transformative initiatives, have some of the most important roles, such as gathering information, analysing data, democratizing data, and, based on their conclusions, expanding the limits of this arena. Since these conclusions generate new conceptions on the subject and shape the limits of the arena, they have a broad view of events and understand them to create connections and generate meaning. Moreover, they are linked to the other actors as they analyse them, as shown in figure 7.

Figure 7 - Impacts/Performance Researchers



Source: Authors, 2022

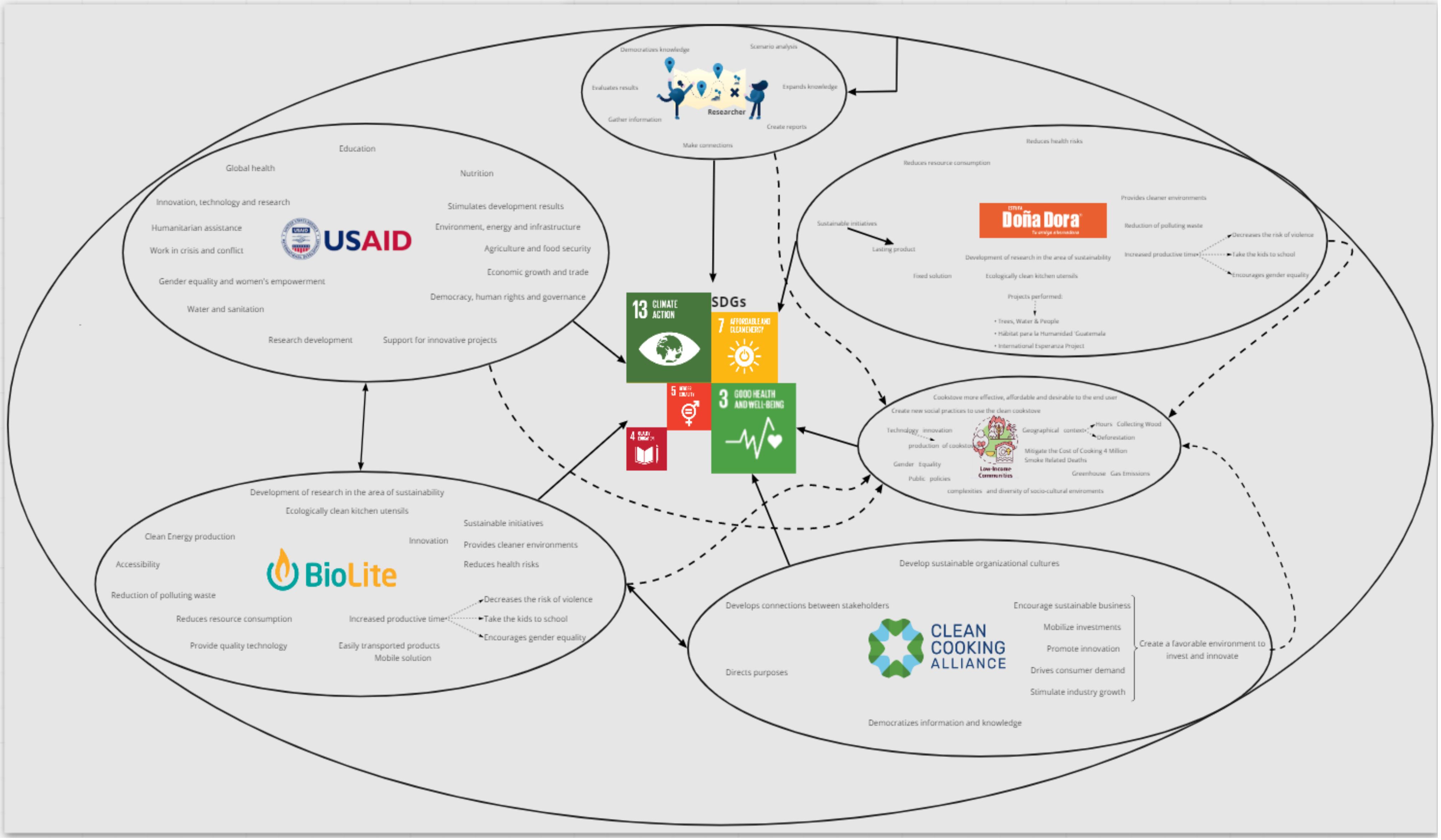
As shown in figure 8, these actors involved can communicate and interact, expanding the boundaries of the arena of the cookstove energy sector. This relationship and sociotechnical stabilization give rise to an actor-world that relates to other actors to continue changing, restructuring, and fostering transition processes. Beyond the mentioned actors, it is possible to imagine others still involved in this transition process. In practice, any entity, idea, or event related to the transition from "polluting cookstoves" to "clean cookstoves" can be considered an actor, as long as it is possible to measure its relevance and validate its performance in order to contribute to the transition.

Taking this as a starting point, we identified other actors and thought of a scale to understand which would be the actors-world originated from these actors. For example, the beneficiary of the project (the one who will acquire the clean cookstove), if he/she is one of the targets to be reached, can be called an actor since his decisions, disposition, the financial and social condition will impact the success of the energy transition. In this way, we can also imagine the community where he/she lives as an actor-world, since it is the relationships between the actors that integrate him/her that will define the limits of this arena. The relationship between this world-actor and the world-actors identified earlier also forms part of the development arena, and their conflicts will move the energy transition forward.

This research allowed us to observe that the changing arena boundaries based on actors' performances in low-income communities in global south countries brought changes in their daily practice routines. For example, people could use efficient, clean cookstoves, promoting their use and making them accessible and affordable acquisition. For this to happen, local government developed policies to regulate microloans and promote better health conditions. The financial institutions promote microloans to buy cooking stoves. The social entrepreneurs develop new clean and efficient cookstoves, promoting new sustainable practices for use in these communities. According to the SDGs, the multilateral agencies formulated and promoted the agenda setting to mitigate the impacts on public health and social and economic development. Furthermore, these agencies generated reports to know the transformation of these communities and identified the lessons learned in these projects. Moreover, the international cooperation agency gave support with economic and technical cooperation and worked together with the multilateral agencies to formulate and promote the agenda setting.

As representatives of research institutions in this study, we aim to democratize, produce and share knowledge to generate new technologies, practices, measures, and more knowledge. Policies and interventions of actors in the cookstove energy sector provided new policies that generated health benefits relative to polluting options, especially for women in the global south. Therefore, new policies in these communities could promote necessary incremental steps toward the cleanest option in the cookstove energy sector to help achieve interim air quality targets toward reaching guideline levels.

Figure 8 – AoD Cookstove Energy Sector



Source: Authors, 2022

Based on the proposition for transformative social innovation of Pel et al. (2020), present social innovation to the involved communities to create more sustainable and healthier conditions to the prior situation, according to table 2.

Table 2 – TSI in the Cookstove Energy Sector

TSI sets of (inter)relations (Pel et al., 2020)	Proposition	Actors
Relations within SI initiatives	Proposition 1. SI initiatives provide spaces in which new or alternative values can be promoted and aligned with new knowledge and practices—in the process of reflexive experimentation that supports both members' motivations and their moves towards collective 'success' and 'impact.'	Research institutions
	Proposition 2. Manifesting new/alternative interpersonal relations is one pivotal way SI actors can create the right conditions to challenge, alter, or replace dominant institutions.	Social entrepreneurs Low income communities
	Proposition 3. People are empowered to persist in their efforts towards institutional change to the extent that basic needs for relatedness, autonomy, and competence are satisfied while simultaneously experiencing an increased sense of impact, meaning, and resilience	Social entrepreneurs Low income communities (women empowerment)
Network formation processes	Proposition 4. The transformative impacts of SI initiatives depend greatly on the changing tensions within and stability of the action field(s) that they operate in.	Local governments
	Proposition 5. Trans-local networks are a key source of empowerment for local SI initiatives.	International cooperation agency Multilateral agency
	Proposition 6. Discourse formation and its mediation through communication infrastructures crucially enhances the reach of SI network formation.	Research institutions Local governments
Institutionalization processes	Proposition 7. SI initiatives need to find an institutional home in order to access vital resources; this often entails a balancing against the desire for independence from (critiqued) dominant institutions.	Local governments Low income communities
	Proposition 8. In order to bring about institutional change, SI initiatives need to combine different forms of institutional entrepreneurship, and proactively adapt these strategies in response to changing circumstances.	Social entrepreneurs Local governments Multilateral Agency
	Proposition 9. SI initiatives reconsider and reconfigure the broader institutional logics in which dominant institutions are embedded, by learning across different institutional logics and by reinventing, recombining and transposing specific elements from one institutional logic to another.	Local governments Low income communities Social Entrepreneurs
The shaping of TSI by the socio-material context	Proposition 10. The rise of SI initiatives and their particular transformative ambitions are strongly shaped by the historical development of the wider socio-material context.	Social Entrepreneurs
	Proposition 11. SI initiatives are only innovative against the background of an evolving socio-material context. Activities of innovating and inventing present but one historical appearance of SI, next to other less conspicuously innovative activities of re-invention, advocacy, and maintenance.	Social Entrepreneurs International cooperation agencies Multilateral agencies
	Proposition 12. Evolutionary diversity is an integral element of TSI processes, reflecting the historical diversity of the transformative ambitions of SI initiatives and the diverse motivations of the people involved in them.	Low income communities Social entrepreneurs Local governments

Source: Authors, 2022

As one can see, the relationship between social entrepreneurs and low-income communities creates social innovation initiatives that transform local cultures and practices, promoting new perspectives for low-income communities through policies, new products, and more accessible services.

5 Conclusion

This research focuses on how actors and locations engaged promote sustainability transitions in the cookstove energy sector. The analysis draws on the principal actors and how the transformation of these territories developed, specifically in global south countries. Arenas of development as an alternative approach to transition analysis in the cookstove energy sector take in the arenas in which actors operate in networks that involve institutions, policies, technologies, visions, and practices (Jørgensen, 2012). Thus, these actors-world cover a lot of different settings far beyond the scope of the cookstove energy sector in this case (Jørgensen & Sørensen, 1999).

In this documental research, the first actors analysed were the low-income communities. However, despite the transformations in the communities, many challenges also exist that need to be solved to contribute to change. For example, knowing the inefficiency, traditional biomass stoves solve many needs of the inhabitants, including cooking food, heating water, heating, drying clothes, and others. The smoke also provides waterproofing for roofs and repels insects in tropical areas. In addition, there are gastronomic traditions with solid cultural roots make it difficult to leave the kitchen quickly, especially in rural homes. Therefore, knowing the conditions is essential to mitigate the problems if it is not enough to insert a new technology to work with the culture and needs of the local environment.

The following actors in this arena, social entrepreneurs, aim to create a clean cookstove that is more efficient, sustainable, and healthy for communities. Besides, they mobilize and contribute to transforming these communities. Nevertheless, even though they affirm that they contribute to reducing inequalities, it does not happen effectively because there are not cultural transformations in terms of gender equity and other issues. Entities like USAID and the Clean Cooking Alliance offer technical and financial support to transform these communities. However, it is not enough to facilitate innovation in these territories as promoters and supporters of impact initiatives because it affects these communities' culture and financial condition to keep these changes in place. Cookstoves is straightforward, but not readily acceptable by the households (Urmee & Gyamfi, 2014). This connection with other actors also occurs through projects. The multilateral agency is a facilitator and promoter of the performance of other actors. It helps in the strategic, organizational, and financial vision of the other initiatives, accelerating this form or the process of transition itself.

According to the analysed documents, in the commercialization of clean cookstoves, the main clients have been international cooperation agencies, governments, and non-

governmental organizations that grant non-reimbursable funds. This condition limits many interventions to offer quality products since the end-user does not know how to operate and verify the technical specifications of the donated product. Thus, in the same documents analysed, the local government does not create conditions for developing effective public policies that can contribute to the design and planning of long-term public policies in the energy, environmental, forestry, and educational areas.
Based on these findings, the most prominent and influential actors involved communicate and interact, expanding the limits of the arena in which they are involved. This relationship and stabilization of the origin of an actor-world that relates to others keeps changing, restructuring itself, and fostering transition processes. In addition, it is possible for the actors involved to imagine others still engaged in this transition process.
With this as a starting point, we identified other actors and thought in scale to understand the actors-world originating from these actors. For example, suppose he/she is one of the targets to be achieved. In that case, the beneficiary of the project (the one who will acquire the clean stove) can be called an actor since his/her decisions, disposition, financial and social condition will impact the success of the transition.
Finally, although this study demonstrated, through the documents analysed, advances for the communities involved and, in particular, women, we consider that this research also has limitations. For example, it is documentary research from the point of view of Biolite and Doña Dora entrepreneurs and USAID and Clean Cooking Alliance, both multilateral agencies which focus on financing policies associated with the SDGs of the 2030 world agenda. Given this, we consider that research conducted with people (particularly women) and their communities would be fundamental to understand better the effects of these technological strategies in relation to the expectations and needs of these communities. For example, ethnographic studies could provide a much broader understanding of this issue and the effects resulting from the insertion or sale of these technologies under analysis and other potential strategies for this and other problems related to the energy field.

References

Ackah, I., Bukari, D., Banye, E. Z., & Bobio, C. (2021). Transitioning towards cleaner cooking fuels: an analysis of consumer preferences in Ghana’s cookstoves market. *Environmental Science and Pollution Research*, *28*(39), 54936–54949. https://doi.org/10.1007/S11356-021-14456-7/TABLES/5

Aemro, Y. B., Moura, P., & de Almeida, A. T. (2021). Inefficient cooking systems a challenge for sustainable development: a case of rural areas of Sub-Saharan Africa. *Environment, Development and Sustainability*, *23*(10), 14697–14721. https://doi.org/10.1007/S10668-021-01266-7

Avelino, F., Wittmayer, J. M., Pel, B., Weaver, P., Dumitru, A., Haxeltine, A., Kemp, R., Jørgensen, M. S., Bauler, T., Ruijsink, S., & O'Riordan, T. (2019). Transformative social innovation and (dis)empowerment. *Technological Forecasting and Social Change*, *145*, 195–206. https://doi.org/10.1016/j.techfore.2017.05.002

Boudewijns, E. A., Trucchi, M., van der Kleij, R. M. J. J., Vermond, D., Hoffman, C. M., Chavannes, N. H., van Schayck, O. C. P., Kirenga, B., & Brakema, E. A. (2022). Facilitators and barriers to the implementation of improved solid fuel cookstoves and clean fuels in low-income and middle-income countries: an umbrella review. *The Lancet Planetary Health*, *6*(7), e601–e612. https://doi.org/10.1016/S2542-5196(22)00094-8

Carrión, D., Prah, R., Gould, C. F., Agbokey, F., Mujtaba, M., Pillarisetti, A., Tumasi, M., Agyei, O., Chillrud, S., Tawiah, T., Jack, D., & Asante, K. P. (2020). Using longitudinal survey and sensor data to understand the social and ecological determinants of clean fuels use and discontinuance in rural Ghana. *Environmental Research Communications*, *2*(9), 095003. https://doi.org/10.1088/2515-7620/ABB831

Carrión, D., Prah, R., Tawiah, T., Agyei, O., Twumasi, M., Mujtaba, M., Jack, D., & Asante, K. P. (2021). Enhancing LPG Adoption in Ghana (ELAG): A Trial Testing Policy-Relevant Interventions to Increase Sustained Use of Clean Fuels. *Sustainability 2021, Vol. 13, Page 2213*, *13*(4), 2213. https://doi.org/10.3390/SU13042213

Dickinson, K. L., Piedrahita, R., Coffey, E. R., Kanyomse, E., Alirigia, R., Molnar, T., Hagar, Y., Hannigan, M. P., Oduro, A. R., & Wiedinmyer, C. (2019). Adoption of improved biomass stoves and stove/fuel stacking in the REACCTING intervention study in Northern Ghana. *Energy Policy*, *130*, 361–374. https://doi.org/10.1016/J.ENPOL.2018.12.007

Fingleton-Smith, E. (2022). Smoke and mirrors—the complexities of cookstove adoption and use in Kenya. *Environment, Development and Sustainability*, *24*(3), 3926–3946. https://doi.org/10.1007/S10668-021-01595-7

Gay, L. R., Mills, G. E., & Airasian, P. (1996). Educational research: Competencies for analysis and applications (ed.). Upper Saddle River, NJ: Merrill.

Goswami, A., Bandyopadhyay, K. R., & Kumar, A. (2017). Exploring the nature of rural energy transition in India: Insights from case studies of eight villages in Bihar. *International Journal of Energy Sector Management*, *11*(3), 463–479. https://doi.org/10.1108/IJESM-11-2016-0001

Heiskanen, E., Apajalahti, E.-L., Matschoss, K., & Lovio, R. (2018). Incumbent energy companies navigating energy transitions: strategic action or bricolage?

Environmental Innovation and Societal Transitions, *28*, 57–69. https://doi.org/10.1016/j.eist.2018.03.001

Hooper, L. G., Dieye, Y., Ndiaye, A., Diallo, A., Sack, C. S., Fan, V. S., Neuzil, K. M., & Ortiz, J. R. (2018). Traditional cooking practices and preferences for stove features among women in rural Senegal: Informing improved cookstove design and interventions. *PLOS ONE*, *13*(11), e0206822. https://doi.org/10.1371/JOURNAL.PONE.0206822

Jewitt, S., Smallman-Raynor, M., K C, B., Robinson, B., Adhikari, P., Evans, C., Karmacharya, B. M., Bolton, C. E., & Hall, I. P. (2022). Domesticating cleaner cookstoves for improved respiratory health: Using approaches from the sanitation sector to explore the adoption and sustained use of improved cooking technologies in Nepal. *Social Science & Medicine (1982)*, *308*, 115201–115201. https://doi.org/10.1016/J.SOCSCIMED.2022.115201

Jørgensen, M. S., Jørgensen, U., & Jensen, J. S. (2017). Navigations and governance in the Danish energy transition reflecting changing Arenas of Development, controversies and policy mixes. *Energy Research & Social Science*, *33*, 173–185. https://doi.org/10.1016/J.ERSS.2017.09.034

Jørgensen, U. (2012). Mapping and navigating transitions - The multi-level perspective compared with arenas of development. *Research Policy*, *41*(6), 996–1010. https://doi.org/10.1016/j.respol.2012.03.001

Jørgensen, U., & Sørensen, O. H. (1999). Arenas of development - A space populated by actor-worlds, artefacts, and surprises. *Technology Analysis and Strategic Management*, *11*(3), 409–429. https://doi.org/10.1080/095373299107438

Kar, A., & Zerriffi, H. (2018). From cookstove acquisition to cooking transition: Framing the behavioural aspects of cookstove interventions. *Energy Research & Social Science*, *42*, 23–33. https://doi.org/10.1016/J.ERSS.2018.02.015

Koop, S. H. A., & van Leeuwen, C. J. (2017). The challenges of water, waste and climate change in cities. *Environment, Development and Sustainability*, *19*(2), 385–418. https://doi.org/10.1007/s10668-016-9760-4

Loorbach, D. (2010). Transition Management for Sustainable Development: A Prescriptive, Complexity-Based Governance Framework. *Governance*, *23*(1), 161–183. https://doi.org/10.1111/J.1468-0491.2009.01471.X

Maji, P., & Kandlikar, M. (2020). Quantifying the air quality, climate and equity implications of India's household energy transition. *Energy for Sustainable Development*, *55*, 37–47. https://doi.org/10.1016/J.ESD.2019.11.006

Markard, J. (2017). Sustainability transitions: Exploring the emerging field and its relations to management studies. *Academy of Management Proceedings*, *2017*(1), 14100. https://doi.org/10.5465/ambpp.2017.14100abstract

Mazzone, A., Cruz, T., & Bezerra, P. (2021). Firewood in the forest: Social practices, culture, and energy transitions in a remote village of the Brazilian Amazon. *Energy Research & Social Science*, *74*, 101980. https://doi.org/10.1016/J.ERSS.2021.101980

Medina, P., Berrueta, V., Cinco, L., Ruiz-García, V., Edwards, R., Olaya, B., Schilmann, A., & Masera, O. (2019). Understanding Household Energy Transitions: From Evaluating Single Cookstoves to "Clean Stacking" Alternatives. *Atmosphere 2019, Vol. 10, Page 693*, *10*(11), 693. https://doi.org/10.3390/ATMOS10110693

Menghwani, V., Zerriffi, H., Dwivedi, P., Marshall, J. D., Grieshop, A., & Bailis, R. (2019). Determinants of Cookstoves and Fuel Choice Among Rural Households in India. *EcoHealth*, *16*(1), 21–60. https://doi.org/10.1007/S10393-018-1389-3/TABLES/21

Pachauri, S., Poblete-Cazenave, M., Aktas, A., & Gidden, M. J. (2021). Access to clean cooking services in energy and emission scenarios after COVID-19. *Nature Energy 2021 6:11*, *6*(11), 1067–1076. https://doi.org/10.1038/s41560-021-00911-9

Pel, B., Haxeltine, A., Avelino, F., Dumitru, A., Kemp, R., Bauler, T., Kunze, I., Dorland, J., Wittmayer, J., & Jørgensen, M. S. (2020). Towards a theory of transformative social innovation: A relational framework and 12 propositions. *Research Policy*, *49*(8). https://doi.org/10.1016/j.respol.2020.104080

Ravindra, K., Kaur-Sidhu, M., Mor, S., Chakma, J., & Pillarisetti, A. (2021). Impact of the COVID-19 pandemic on clean fuel programmes in India and ensuring sustainability for household energy needs. *Environment International*, *147*. https://doi.org/10.1016/J.ENVINT.2020.106335

Schilmann, A., Ruiz-García, V., Serrano-Medrano, M., De La Sierra De La Vega, L. A., Olaya-García, B., Estevez-García, J. A., Berrueta, V., Riojas-Rodríguez, H., & Masera, O. (2021). Just and fair household energy transition in rural Latin American households: are we moving forward? *Environmental Research Letters*, *16*(10), 105012. https://doi.org/10.1088/1748-9326/AC28B2

Serrano-Medrano, M., García-Bustamante, C., Berrueta, V. M., Martínez-Bravo, R., Ruiz-García, V. M., Ghilardi, A., & Masera, O. (2018). Promoting LPG, clean woodburning cookstoves or both? Climate change mitigation implications of integrated household energy transition scenarios in rural Mexico. *Environmental Research Letters*, *13*(11), 115004. https://doi.org/10.1088/1748-9326/AAD5B8

Sharp, D., & Salter, R. (2017). Direct impacts of an urban living lab from the participants' perspective: Livewell Yarra. *Sustainability (Switzerland)*, *9*(10). https://doi.org/10.3390/su9101699

Sillig, C. (2022). The role of ideology in grassroots innovation: An application of the arenas of development framework to organic in Europe. *Ecological Economics*, *191*, 107252. https://doi.org/10.1016/J.ECOLECON.2021.107252

Sovacool, B. K., & Griffiths, S. (2020). The cultural barriers to a low-carbon future: A review of six mobility and energy transitions across 28 countries. *Renewable and Sustainable Energy Reviews*, *119*, 109569. https://doi.org/10.1016/J.RSER.2019.109569

Sovacool, B. K., Hess, D. J., Amir, S., Geels, F. W., Hirsh, R., Medina, L. R., Miller, C., Palavicino, C. A., Phadke, R., Ryghaug, M., Schot, J., Silvast, A., Stephens, J., Stirling, A., Turnheim, B., Vleuten, E. van der, Lente, H. van, & Yearley, S. (2020). Sociotechnical agendas: Reviewing future directions for energy and climate research. *ENERGY RESEARCH \& SOCIAL SCIENCE*, *70*. https://doi.org/10.1016/j.erss.2020.101617

The cost of inequality. (2022). *Nature Sustainability*, *5*(2), 89. https://doi.org/10.1038/s41893-022-00860-5

Urmee, T., & Gyamfi, S. (2014). A review of improved Cookstove technologies and programs. *Renewable and Sustainable Energy Reviews*, *33*, 625–635. https://doi.org/10.1016/J.RSER.2014.02.019

Valderrama Pineda, A. F., & Jørgensen, U. (2016). Creating Copenhagen's Metro - On the role of protected spaces in arenas of development. *Environmental Innovation and Societal Transitions*, *18*, 201–214. https://doi.org/10.1016/j.eist.2015.05.002

Wang, Y., & Bailis, R. (2015). The revolution from the kitchen: Social processes of the removal of traditional cookstoves in Himachal Pradesh, India. *Energy for Sustainable Development*, *27*, 127–136. https://doi.org/10.1016/J.ESD.2015.05.001

WHO. 2014. "Burden of Disease from Household Air Pollution for 2012." WHO Public Health, Social and Environmental Determinants of Health Department. Geneva. http://www.who. int/phe/health_topics/outdoorair/databases/HAP_BoD_results_March2014.pdf?ua=1.

Wiedinmyer, C., Dickinson, K., Piedrahita, R., Kanyomse, E., Coffey, E., Hannigan, M., Alirigia, R., & Oduro, A. (2017). Rural–urban differences in cooking practices and exposures in Northern Ghana. *Environmental Research Letters*, *12*(6), 065009. https://doi.org/10.1088/1748-9326/AA7036

Culture and Transition Design in the Fashion System

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Abstract.
This research investigates the possibilities of design as a strategic framework for harnessing the transformative potential of the sociocultural dimension in types of innovation that enable a sustainable transformation of the fashion industry. Creative Economics has identified various impacts of culture on a diversity of innovation levels, but this causal relationship, by assuming culture as a "soft" component of innovation, undervalues its capacity for agency, which has been a claim in cultural sociology and fashion studies.
To fill this research gap, this article adopts Design for Sustainability (DfS), a recent perspective that integrates strategic design into systemic innovations. This framework is better suited to connect a transformative conception of culture as it understands systemic innovation in terms of structuration processes catalyzed by design.
The DfS framework is used as a lens for reviewing the literature around the connections between design and cultural-based innovation towards sustainability. 32 references are analysed under a transdisciplinary heuristic tool that allows integrating culture, design and systems innovation in fashion, and the selection criteria of the references analyzed.
The results map a multiplicity of approaches that privilege the cultural dimension of fashion system such as craftsmanship, fashion design activism or social fashion design, and allow us to explain why these cultural practices, instead of marginal, should be considered as potentially transformative.
These results suggest that cultural economics should include the transitional perspective of design to increase the value of culture in innovation and, on the other hand, that a cultural turn of innovation, as proposed here, would improve the analytical capacity of the DfS approach.

1 Introduction

The production and consumption model of the fashion industry has severe environmental and social impacts. Each phase along its value chain generates a variety of environmental damage: high levels of water pollution, production of synthetic fibers and a global transportation network based on oil, low levels of recycling, high waste generation in the form of landfills and burning of clothes (Fashion Revolution, 2019; Peters, Li, & Lenzen, 2021; Šajn, 2019; Scheffer, 2012). Additionally, the offshoring dynamics and efficiency of suppliers has led to a sweatshop model based on the exploitation of labor markets with very low levels of qualification (Kumar, 2020), while has provoked a deep crisis in traditional industrial clusters as European regions.

Innovation appears as the way to make economic growth compatible with environmental goals (Voß, 2010). In this sense, most of the sustainability endeavors in textile and clothing industry are focused on technical aspects and consumer's awareness as production of new ecologic materials, sustainable value chains or circular economy.

Although this industry is recognized as the quintessence of low innovation (Scott, 2006; Taplin, 2006), some clusters have managed a knowledge-intensive specialization such as the German textile industry, but, others territories traditionally oriented by the design and fashion industry -such as southern Europe- look for a different specialization more oriented to the symbolic dimension of fashion.

The Creative Economy and design studies have made great strides in this direction, while a variety of European projects[1] have addressed this larger question by connecting and experimenting synergies between creative and cultural sectors and the T&C industry.

However, the consideration of culture as a "symbolic", "soft" or "hidden" dimension of innovation (Asheim & Hansen, 2009; Green, Miles, & Rutter, 2007; Stoneman, 2010) makes it a contextual or external variable of transformation, which is in contradiction with cultural sociology that places culture at the center of the structuring and agency, (Hays, 1994; Spillman, 1996), two processes that energize the social institutionalization and reflexivity that underpin sustainable transitions (Geels, 2004).

In this research, fashion is proposed as a revealing case that evidences the need for a new approach to innovation. There is a set of sustainable fashion practices, such as social designers, social activists, organized communities of artisans or entrepreneurs, which constitutes the "cultures of sustainable fashion" (Thomas, 2020), that explore how to transform the social values that underpin the unsustainable socio-productive model of fast fashion. This practices exceed economic-centered and sectorial

[1] WEAR Sustain https://wearsustain.eu/dashboards/home
WORTH: https://www.worthproject.eu/worth-project/
Createx: http://createxproject.eu/
TCBL: https://tcbl.eu/
CreativeWear: https://creativewear.interreg-med.eu/

approaches on culture and innovation, and demand a systemic and human centered perspective.

Therefore, this research adopts the Design for Sustainability (DfS) (Ceschin & Gaziulusoy, 2020, pp. 124–141; İ. Gaziulusoy & Erdoğan Öztekin, 2019), an emerging approach that maps different strategic levels where design operates as a catalyst of radical sustainable innovations, not only at the product level, but - and more relevant - at the socio-technical system level, in which case it is defined as Design for Sustainability Transitions (DfST).

As part of the social system, cultural transitions are understood as incremental and long-term processes, but design becomes a promising framework for energizing radical transformations in institutionalized norms and values. Through the case of fashion practices, this research asks:

How can Design for Sustainable Transitions contribute to an understanding of the role of culture in the transformation of the fashion system?

This question is addressed on sustainable fashion practices reported in the academic literature. The DfS allows to sieve the multitude of fashion practices into those that intersect culture, design and sustainability oriented to systemic transformation of fashion that results in 32 academic references, selected through a heuristic tool (I. Gaziulusoy & Boyle, 2012) which allows a transdisciplinary comprehension of this complex study object.

The filter of DfS allows to stablish which fashion practices point to socio-technical transitions, identifying different applications of design, for instance, product-services systems for sustainable fashion, participatory fashion design, social and community design, fashion design as political action, among others, that

2 The cultural dimension of Design for Sustainability

The theoretical approach combines a sociological conception of culture and the DfS approach.

2.1 The concept of culture in the processes of structuring and agency

Culture in sociology is understood as a comprehensive dimension of social change. This "cultural turn" of sociology (Wolff, 1999) are based on two conceptual shifts: first, it brings cultural studies from the humanities closer to the typical categories of sociology such as the processes of structuration and agency (Hays, 1994; Spillman, 1996) and, second, it discard the objectivism and neutrality of sociological categories, putting in the first place the "*discursive nature of social relations and institutions*" (Wolff, 1999, p. 23), and include the dimension of power and politics of signification (Storey, 2005) in the study of social change.

The structuring definition of culture is clearly developed in Pierre Bourdieu's sociology, in which the concepts of habitus and field remove from culture, as well as from sociology in general, the traditional theoretical dispute between domination and individualism (Bourdieu, 1983).

On the other hand, however, the new status of culture as a comprehensive category, does not erase the role of subjectivity and representation, nor does it relegate its proximity to post-structural definitions of power and narratives in the processes of institutionalization and social action (Wolff, 1999).

The relevance of the "cultural turn" is that, while it erodes the idea of culture as a "tool kit" from which the "action strategies" of individuals derive, it brings culture closer to the study of other much broader dimensions such as economics, education or industrial sociology (Wolff, 1999).

2.2 Design for Sustainability (DfS)

The Design for Sustainability -DfS- (Ceschin & Gaziulusoy, 2020) provides both conceptual and strategic elements: on the one hand, it corresponds to a map of the different levels of sustainable innovation and, on the other, to the strategic factors that condition the emergence of radical innovations in the system.

2.2.1 Innovation levels:

According to the emerging approach, strategic design introduces sustainable improvements at a variety of innovation levels, from material and product design to social system design. The first type is more technology-centered and is performed for isolated agents, while the systemic level is more collective and human-centered.

The novelty of this approach is the recognition of the capacity of design to produce radical innovations at the system level, something traditionally associated with incremental and long-term processes (Gaziulusoy & Brezet, 2015).

In concrete, the DfS (Ceschin & Gaziulusoy, 2020, p. 145) draws five strategic innovation levels:

- **Material/component**: improvements in the material characteristics of products oriented to reduce its environmental impact.
- **Product design:** changes in the product considering its complete lifecycle.
- **Product Service Systems (PSS):** Design oriented to services generation that substitutes product by integrating multi-actors, services and value chains.

- **Spatio-social innovations:** Production of social innovations that improve sustainability demands at different levels: community, district or big urban areas.
- **Socio-technical systems:** Design process of radical innovations in the high level system transitions.

Illustration 1 schematizes the innovation levels in which design intervene to produce sustainability.

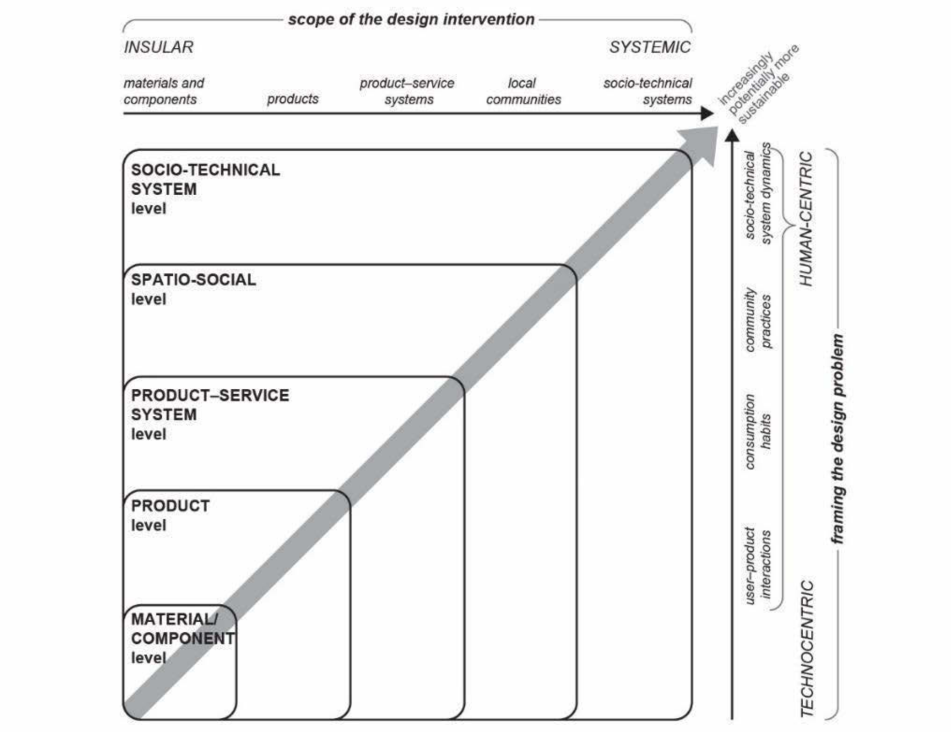

Illustration 1. The Design for Sustainability Framework. (Ceschin & Gaziulusoy, 2020 pp. 144).

2.2.2 Design for Sustainable Transitions (DfST)

In the higher level, design is rendered at the socio-technical level and it is called Design for Sustainability Transitions (DfST) (Ceschin & Gaziulusoy, 2016, 2020; A. I. Gaziulusoy & Brezet, 2015; Joore & Brezet, 2015; Tischner, 2008; Vezzoli et al., 2018). And is defined as the set of design practices applied in a multiplicity of technological or social domains, in which design provides environmentally (Vezzoli et al., 2018) and socially (Tischner, 2008) sustainable solutions, either with a focus on sustainable development (Vezzoli et al., 2018) or degrowth (A. I. Gaziulusoy & Houtbeckers, 2018)

Socio-technical transitions, in fact, can be defined as reflexive processes that require co-design of cyclical and iterative phases of experimentation (Grin, Rotmans, & Schot, 2010).

On the other hand, the beginnings of the DfST are related to the need to design "cultural change" (Ceschin & Gaziulusoy, 2020, p. 125), which is very telling in terms of the suitability of the DfST for the analysis of cultural innovation processes.

2.3 Theoretical proposal: Culture and the DfS

Although the literature has advanced in an articulation between strategic design and the systemic innovation approach, it would be conceptually and methodologically appropriate to include the concept of culture, in order to know to what extent those culturally based initiatives that question dominant production and consumption models can be defined as socio-technical transitions.

In other words, whether the field of culture, in the form of cultural practices that involves different forms of agency as social participation, social activism from artistic activities, community organizations or alternative lifestyles and values, deserves a status of validity (scientific, political, social) as a field of experimentation of transitions.

In this sense, the theoretical proposal of this research takes into account the sociological turn taken by the concept of culture, as mentioned in section 2.1, i.e., as an active dimension within the social processes of structuration.

Given that system innovation is a societal embedded process (Kanger, Geels, Sovacool, & Schot, 2019), i.e., that the dynamics of stability and transition are subordinated to changes in social and cultural schemas, as well as to material and technological aspects, then the integration of culture into the analysis of fast fashion from a socio-technical perspective seems to be promising at the conceptual and methodological level.

In order to synthesize an analytical tool based on this theoretical proposal, three analytical levels are proposed, as summarized in Table 1.

First, to ask what kind of meanings and normative structures are addressed in a particular cultural practice, what part of the dominant sociotechnical regime is articulated, and what elements allow a cultural practice to stop being considered marginal and become a valid space of system transformation.

Secondly, to know what levels of systemic approach are proposed in a specific cultural practice, i.e., whether the transforming proposal is more insular or holistic.

And thirdly, how a human-centered approach is approached, whether it is done from a *very* technological perspective of innovation or whether technologies are understood to be the product of a social construction process.

Table 1. Analytical tool for the design of a Strategic Niche Management of cultural practices. Source: Author.

Dimension of analysis	Type of fashion practice
Type of rules, meanings	• Main experimented concepts, normative structures or meanings.
System approach	• Relative distance from isolated or holistic approach of innovation
Human centered	• Prevalence of a semiotic or social construction of technologies over functionality of technologies
References	• (Bibliographic references)

These dimensions help establish the relative distances between a systemic and a human-centered approach to innovation and provide the grid references for mapping cultural practices on the DfS map.

3 A transdisciplinary Methodology and Analysis

When a researcher begins to search the literature on fashion, culture and design sustainability, he or she faces the problem of the multiplicity of fields of knowledge, actors and type of publications that generates a large number of references. Therefore, it is necessary to establish a search and selection logic that simplifies and integrates the object of study across disciplines and provides sufficient methodological soundness.

The transdisciplinary approach (Gaziulusoy, 2015; Gaziulusoy & Boyle, 2012; Huutoniemi & Tapio, 2014; Pohl, 2014) make it possible to integrate a framework of analysis that cuts across the disciplines involved and delimit and systematize the selection of bibliographic sources.

This methodological turn is concretized in a heuristic tool, as described in Gaziulusoy & Boyle, aiming to help transdisciplinary researchers *"in systematic structuring and prioritization of literature review/reporting process*" (2012, p. 140). The heuritstic tool makes disciplines talk each other and provides the boolean operators for search on databases and the selection criteria.

The transdisciplinary approach is ideal for the research topic because it focuses on solving socially relevant problems; it establishes methodological collaboration between disciplines; it involves knowledge from non-scientific perspectives and is *"normative, i.e. [it] aim[s] to transform the problem domain"* (I. Gaziulusoy & Boyle, 2012, p. 139). On the other hand, the heuristic tool helps individual researchers because it reduces the research infrastructure that requires in-depth analysis in specialized disciplines (I. Gaziulusoy & Boyle, 2012, pp. 139–140).

According to Gaziulusoy & Boyl (2012), it works in two dimensions: first, a four-level pyramid that simplifies the variety of disciplines into four levels: empirical, pragmatic, normative and value-based, each of which corresponds to basic disciplines (sciences); applied disciplines; planning or policy; and philosophy or ethics. All these disciplines produce knowledge relevant to the research.

However, in order to select the references among this myriad of publications, the second dimension is necessary, which comprises three types of knowledge: knowledge of systems, of objectives and of transformation. They refer, respectively, to the current state of knowledge, the desired state and the strategies to achieve the latter.

As can be expected, the volume of publications on design, sustainability and culture in the textile and apparel industry is large. The first step of the research was a search under the terms sustainability, design and culture in the mentioned industry which drastically limited the amount of publications in the fields of social sciences, economics, management, industrial studies, design studies, among others, however, it resulted still complicated and unmanageable.

A second major methodological step was to use the second heuristic dimension to find out which of the publications situate knowledge production in terms of transformation, resulting in a primary search field, which refines the terms transition, instead of innovation, culture and change, instead culture; redesign, instead of design; and fashion system, instead of the textile and apparel industry (Figure 2). This new field introduces into the search the current crisis of sustainability and the transformative and systemic dimensions.

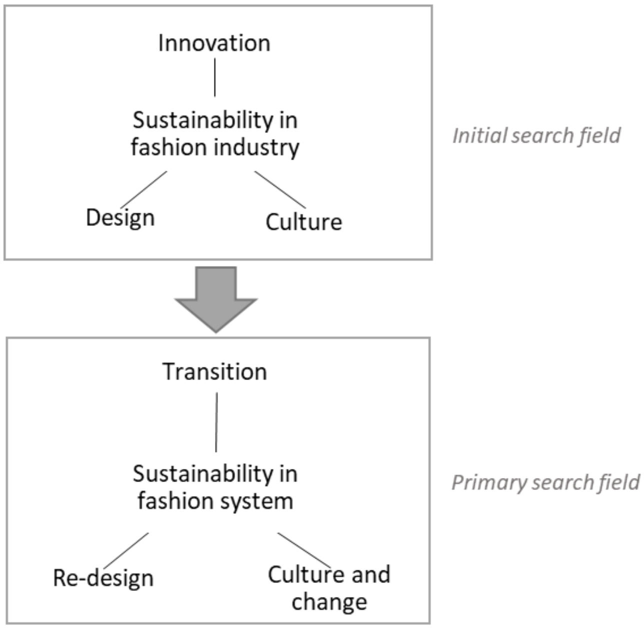

Illustration 2. Transdisciplinary approach for the search and prioritization of references.

This primary field of research provides the boolean search commands that were applied in the major social science and innovation databases such Scopus, Web of Science, Google Scholar, ProQuest, JSTOR and Google. This systematic search was complemented by a "snowballing" strategy that made it possible to add references that had not been considered. The search results were refined by discarding and adding references not included in the operators, resulting in a list of 32 references.

4 Results

The results show that the fashion practices studied can be classified according to the different levels of innovation of the DfS framework, i.e., references to sustainable fashion product-service systems, participatory fashion design, community-based initiatives; redesign of fashion value chains and systemic fashion markets can be identified. The analysis tool made it possible to achieve these results.

4.1 Analysis process

The analysis process consists of the evaluation of an individual source with the analysis tool (Table 1.). A particular source is considered to carry one or more fashion practices, implicitly or explicitly.

A second analytical step is the positioning on the DfS map. The analysis tool provides the coordinates that make it possible to locate specific fashion practices on the conceptual map.

Once located, it was possible to establish clusters of sources that allow classifications and the emergence of analytical categories.

These categories were finally detailed in a structured explanation, which constitutes the results of the research.

Two examples of the application of the analysis tool are presented here, illustrating, in the first case, how the systemic approach is addressed in the specific practice of fashion activism and participatory design. It assumes fashion as an explicitly political practice. It also makes clear the human-centered strategy based eon emotional design and the type of consumer meanings and value creation it aims to transform.

Table 2. First example of the analysis process.

Dimension of analysis	**Fashion activism and participatory design**
Type of rules, meanings	• Consumer awareness, value creation of clothes by emotions and personal production
System approach	• Design activists refers to “who challenge the current practices with design thinking to improve the environment and society”. • “non-aligned social broker and catalyst; a facilitator; an author; a creator; a co-author; and a happener”.

	• Fashion Activism is in the same way a political activity and participatory approach to empower the consumer to be independent from the fashion industry.
Human centered	• Emotional person-product attachment, half-way design approach, “do it yourself”, personal engagement, re-design.
References	• (A. Hirscher & Niinimäki, 2015)

A second example illustrates a fashion practice that is systemic but market-centered rather than human-centered. Its perspective is systemic because it understands change not only as a market or economic issue, but requires the involvement of institutional, social, scientific and cultural changes.

Table 3. Second example of the analysis process

Dimension of analysis	**Fashion activism and participatory design**
Type of rules, meanings	• Change in mindsets of industrials, institutions and research actors.
System approach	• Market Systems Dynamics approach • Role of institutionalization processes as a condition of sustainable change
Human centered	• Minimal reference to cultural change
References	• (Dolbec & Fischer, 2015; Ghaffari, Jafari, & Sandikci, 2019; A. Hirscher & Niinimäki, 2015; Ozdamar Ertekin, Atik, & Murray, 2020)

After this analytical exercise it was possible to map the fashion practices according to the DfS model.

4.2 Fashion Practices in the Design for Sustainability Framework

4.2.1 Level 1 and 2. Materials and products:

Systems design covers a very broad scope of innovation, at the material level it includes the introduction of fibers and fabrics, sustainable product design such as cradle-to-cradle and product life cycle assessment. It also includes value chain redesign in the fashion industry and environmental standards.

Co-design practices are applied in the introduction of new sustainable fashion products (Hur, Beverley, & Cassidy, 2013). Branding is included in this subgroup as a design strategy by which to generate sustainable values in fashion consumers (Kozlowski, Searcy, & Bardecki, 2016; Moorhouse & Moorhouse, 2018). Life Cycle Assessment is also addressed in order to identify and design strategies to reduce impacts in the specific value chain stages of fashion industry (Kozlowski, Bardecki, & Searcy, 2012).

4.2.2 Level 3. Product Service-system (PSS):

A network of practices based on the PSS design can compose a sustainable fashion value chain, as Azzi, Vezzoli & Conti proposes, designing a scenario which includes do-it-yourself clothes, community clothing clubs, shared wardrobes, as ongoing existing fashion practices (Azzi, Vezzoli, & Conti, 2020).

Other practices can be located as design services modality, with some conceptual and methodological distances from a very PSS vision. For instance, the designing of sustainable tools for institutions and industry, beyond standards and green innovations perspective (Kozlowski, Bardecki, & Searcy, 2019).

On the other hand, there are some practices based on co-design of services closer to a participatory approach of consumers (Hur et al., 2013).

4.2.3 Level 4. Spatio-social:

When co-design goes beyond individual consumers, towards the involvement of communities in a participatory approach, and is articulated as a fashionable political proposal, these practices can be considered as a spatio-social version of design.

Table 4. Classification of consulted references according to Design for sustainability innovation levels.

DfS levels	Typology of culture-based design for sustainability in fashion system	References
Material/component	Sustainable T&C design	Torres & Gardetti, 2013
Product	Life Cycle Assessment	Kozlowski, Bardecki, & Searcy, 2012
	Branding and business models design	Kozlowski, Searcy, & Bardecki, 2016
	Sustainable Branding	Moorhouse & Moorhouse, 2018
	Systemic markets	Ozdamar Ertekin, Atik, & Murray, 2020
Product-Service System	Tools for Sustainable Fashion Design	Kozlowski, Bardecki, & Searcy, 2019
	Product-Service System for sustainable fashion	Azzi, Vezzoli, & Conti, 2020
	Co-design	Hur, Beverley, & Cassidy, 2013
	Co-design craft	Hur & Beverley, 2013
	Service design	Mazzarella, Mitchell, & Escobar-Tello, 2017
	Branding and social innovation	Bertola et al., 2020
Spatio-Social	Participatory design	McHattie, Champion, & Broadley, 2018
		A.-L. Hirscher & Fuad-Luke, 2013
	Ethical Economy: social production and new values creation	A.-L. Hirscher, Mazzarella, & Fuad-Luke, 2019
		Hirscher, Niinimäki, & Joyner Armstrong, 2018
	Fashion activism	Hirscher, 2013
		Busch, 2008
		A. Hirscher & Niinimäki, 2015
		The Fashion Practice Collective, 2014
	Social movements and industry transformation	Thomas, 2020
Socio-Technical System	Design strategies from a consumer perspective	Niinimäki & Hassi, 2011
	Ethics in sustainable fashion system	Niinimäki, 2015
	Fashion sustainability as institutional processes	Gupta, Gwozdz, & Gentry, 2019
	Sustainability and responsability	Boström & Micheletti, 2016
	Post-growth and fashion	Taylor, 2019
	Cultural-based design	Bertola et al., 2016
	"Slow Fashion"	Fletcher, 2014
	Craftmanship and transition	Vuletich, 2015

Source: Author.

Social innovations in this level consists in creating new values about our social and individual relationship with the production and consumption of clothing based on different fields of application, actors at play and objectives of change. For example, the role of service design to promote artisan communities who generate "meaningful routes" (Mazzarella, Mitchell, & Escobar-Tello, 2017) towards more sustainable values; similarly, participatory design is applied as a mechanism to connect textile traditions in regional innovation processes (McHattie, Champion, & Broadley, 2018).

Participatory design is proposed as a tool for sustainable alternative economies in fashion industry (A.-L. Hirscher & Fuad-Luke, 2013). On the other hand, design can link in different ways the consumer within the productive process of clothing as social re-appropriation of production to generate an "ethical economy" (A.-L. Hirscher, Mazzarella, & Fuad-Luke, 2019; A.-L. Hirscher, Niinimäki, & Joyner Armstrong, 2018) and, design is also projected as a reflexive and political practice through the concept of fashion activism (Busch, 2008; A. Hirscher, 2013; A. Hirscher & Niinimäki, 2015; The Fashion Practice Collective, 2014).

From a perspective that connects design at the product level with structural changes in the industry system, the work of Niinimäki & Hassi (2011) raises the capacity of design to incorporate consumers' growing demands for sustainability into product innovations. In the same vein, the work of Bertola et al. (2016) proposes that, given

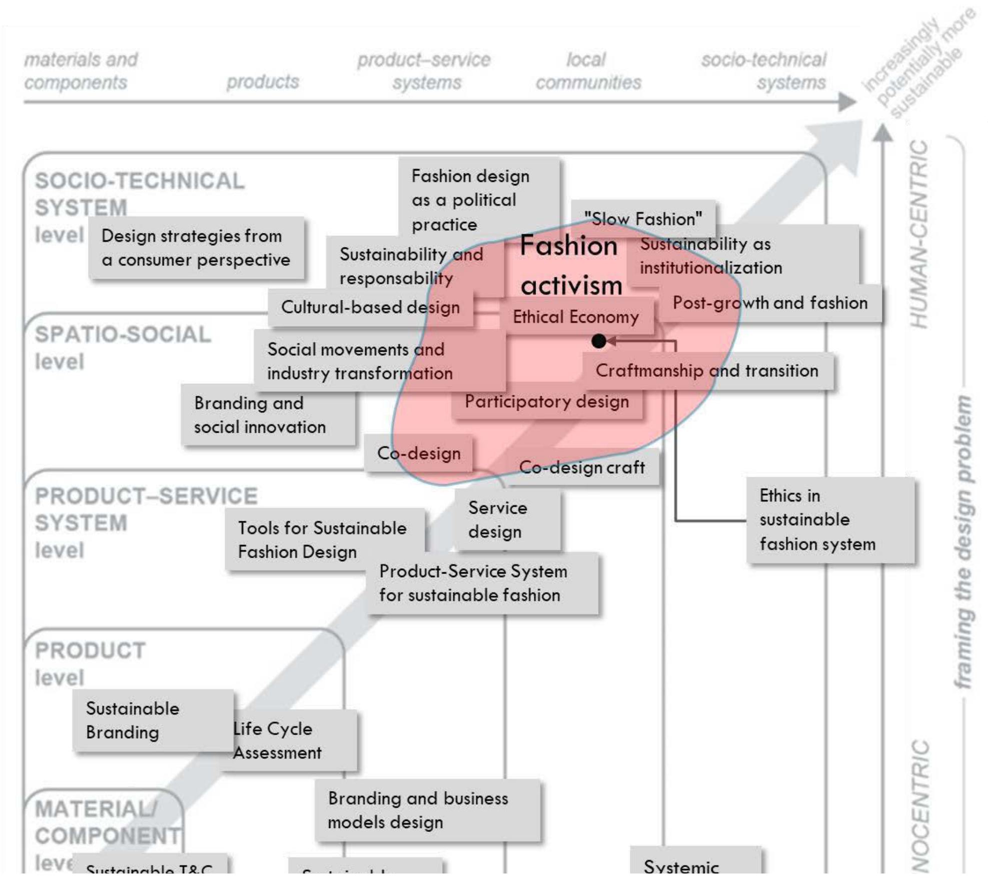

Illustration 3. Fashion practices in the Design for Sustainbility map. Source: Author based on Ceschin & Gaziulusoy, 2020.

the profound change in the concept of innovation represented by the privileging of meaning over functionality, the design of narratives of authenticity plays a fundamental role in the innovation process, especially in culture-intensive industries such as the fashion industry.

4.2.4 Level 5. Socio-technical systems:

Another field of research conceives sustainability as a matter of profound redesign of the fashion system, which is a holistic process that includes not only production or consumption, but understands it to be, in a sociological sense, an institution in whose construction different social, political and economic processes converge. In this sense, Fletcher's Slow Fashion concept is a representative of a transitional perspective of the DfS.

Other fashion practices drives institutionalization processes in a polysemy of dimensions, as, for example, in introducing new market dynamics through processes of convergence (Market System Dynamics - MSD) (Ozdamar Ertekin et al., 2020). But institutionalization is also when all actors are involved in the transformation, where governmental bodies and social agents contribute to the process, e.g. the effort of sustainability of production and consumption (Boström & Micheletti, 2016), or that changes in more sustainable lifestyles, are the collective fruit of the actors who make up the fashion system (Gupta, Gwozdz, & Gentry, 2019). However, for these last cited sources, the systemic perspective is applied in the domain of materials, products, markets or consumers more technologic than human centered.

5 Conclusions

From the results obtained, and addressing the research question of how the DfS can contribute to the understanding of the role of culture in the innovation of the fashion system, it is possible to establish that the proposed framework articulates culture in the innovation of the proposed object of study in a better way than the creative economy. According to the latter, culture and the arts have a linear causal relationship with sectoral innovation in the fashion industry, while the DfS addresses new dynamics in the concept of innovation, according to which it is more systemic and oriented by the construction of social meanings than by technologies and functionality.

But the concept of culture in this framework requires a better attention. It is necessary to adopt a sociological concept of culture that is linked to the capacity for agency, which requires vindicating the sociological relationship between structure and agency, which, additionally, beyond opposing categories, are complementary to each other (Hays, 1994; Spillman, 1996).

The resulting theoretical proposal, based on a combination between DfS and a sociological concept of culture, which is synthesized in the proposed analytical tool, helped to assess the transition perspective of fashion practices in terms of both systemic approach and human-centered transformation.

The results of the analysis provide a classification of these practices in the DfS map of innovation levels. From this exercise derives a new consideration of fashion practices as valid processes of system transformation. Specifically claiming radical fashion, craft activism, hacking design, social processes of clothing production, shared wardrobes, artisanal communities, upcycling, textile traditions or clothing repair and DIY as transformative rather than marginal proposals.

It recognizes the creation of ethical values, the recovery of the relationship between tools, materials and the body as a resignification of our connection with clothing, as alternative values that those fashion practices put into circulation where culture and the arts are constituted as fields of experimentation in which these processes are aligned as proposals for sustainable transition.

6 Discussion

This research results propose an academic and strategical dialogue at two levels:

First a dialogue with socio-technical systems approach:

Fashion system has not been studied from a socio-technical approach: despite its known impacts on sustainability, the definition of the regime and the multiplicity of experimental initiatives is needed. On the one hand, in addition to waste production, low levels of recycling, and social impacts, Fast fashion regime is oil dependent for synthetic fibres production and global transportation networks. On the other hand, there are a myriad of fashion initiatives aiming to regime transformation that can be characterized as innovation niches.

Culture has not been sufficiently integrated in the socio-technical approach: Although it has been initially approached as an understanding of the dynamics of appropriation by users (Geels, 2004), a better articulation of cultural sociology is needed where culture is a structured system of representations that, at the same time, structure social practices.

Culture seems to continue as an independent variable in the transition studies: Power and resistance dynamics are central in the constructivist perspective of culture, but these dimensions of social change, studied in the form of narratives (Hermwille, 2016) or discourse (Rosenbloom, Berton, & Meadowcroft, 2016), in the socio-technical approach, are linked more to the political than to the cultural sphere. Power is itself treated as a political dimension of sustainable transitions (Avelino, 2021).

And, secondly, a dialogue with design studies:

The need to implement a specific design method for cultural-based socio-technical experimentation arises. This includes the implementation of skill sets and attitudes for cultural practitioners, organizations and institutions as designers of sustainable transitions.

Finally, these results call for considering culture *as* a central dimension of sustainability, beyond an intrinsic or instrumental aspect (Soini & Dessein, 2016. Italics in original). This is especially relevant in the circumstances of the current environmental emergency, where the necessary changes are considered more cultural than technological.

References

Asheim, B., & Hansen, H. K. (2009). Knowledge Bases, Talents, and Contexts: On the Usefulness of the Creative Class Approach in Sweden. *Economic Geography*, *85*(4), 425–442. https://doi.org/10.1111/j.1944-8287.2009.01051.x

Avelino, F. (2021). Theories of power and social change. Power contestations and their implications for research on social change and innovation. *Journal of Political Power*, 1–24. https://doi.org/10.1080/2158379X.2021.1875307

Azzi, B., Vezzoli, C., & Conti, G. M. (2020). Design for sustainable fashion: An S. PSS scenario for fashion. In *Textiles, Identity and Innovation: In Touch* (pp. 527–534). CRC Press.

Bertola, P., Vacca, F., Colombi, C., Iannilli, V. M., & Augello, M. (2016). The Cultural Dimension of Design Driven Innovation. A Perspective from the Fashion Industry. *The Design Journal*, *19*(2), 237–251. https://doi.org/10.1080/14606925.2016.1129174

Boström, M., & Micheletti, M. (2016). Introducing the Sustainability Challenge of Textiles and Clothing. *Journal of Consumer Policy*, *39*(4), 367–375. https://doi.org/10.1007/s10603-016-9336-6

Bourdieu, P. (1983). The field of cultural production, or: The economic world reversed. *Poetics*, *12*(4–5), 311–356.

Busch, O. von. (2008). *Fashion-able. Hacktivism and engaged fashion design*. School of Design and Crafts; Högskolan för design och konsthantverk.

Ceschin, F., & Gaziulusoy, I. (2016). Evolution of design for sustainability: From product design to design for system innovations and transitions. *Design Studies*, *47*, 118–163. https://doi.org/10.1016/J.DESTUD.2016.09.002

Ceschin, F., & Gaziulusoy, İ. (2020). *Design for sustainability: A multi-level framework from products to socio-technical systems*. *Design for Sustainability: A Multi-level Framework from Products to Socio-Technical Systems*. Taylor and Francis. https://doi.org/10.4324/9780429456510

Dolbec, P. Y., & Fischer, E. (2015). Refashioning a field? Connected consumers and institutional dynamics in markets. *Journal of Consumer Research*, *41*(6), 1447–1468. https://doi.org/10.1086/680671

Fashion Revolution. (2019). *Fashion Transparency Index*. Retrieved from https://issuu.com/fashionrevolution/docs/fashion_transparency_index_2019

Fletcher, K. (2014). *Sustainable fashion and textiles: design journeys* (Second). Routledge.

Gaziulusoy, A. I., & Brezet, H. (2015). Design for system innovations and transitions: a conceptual framework integrating insights from sustainablity science and theories of system innovations and transitions. *Journal of Cleaner Production*, *108*, 558–568. https://doi.org/10.1016/J.JCLEPRO.2015.06.066

Gaziulusoy, A. I., & Houtbeckers, E. (2018). Convergences: Design for Sustainability Transitions and Degrowth. In *6th International Degrowth Conference, Malmö, Sweden* (pp. 21–25).

Gaziulusoy, I. (2015). A critical review of approaches available for design and innovation teams through the perspective of sustainability science and system innovation theories. *Journal of Cleaner Production*, *107*, 366–377. https://doi.org/10.1016/J.JCLEPRO.2015.01.012

Gaziulusoy, I., & Boyle, C. (2012). Proposing a heuristic reflective tool for reviewing literature in transdisciplinary research for sustainability. In *Journal of Cleaner Production* (Vol. 48, pp. 139–147). Elsevier Ltd. https://doi.org/10.1016/j.jclepro.2012.04.013

Gaziulusoy, İ., & Erdoğan Öztekin, E. (2019). Design for Sustainability Transitions: Origins, Attitudes and Future Directions. *Sustainability*, *11*(13). https://doi.org/10.3390/su11133601

Geels, F. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, *33*(6–7), 897–920. https://doi.org/10.1016/j.respol.2004.01.015

Ghaffari, M., Jafari, A., & Sandikci, O. (2019). The role of mundane and subtle institutional work in market dynamics: A case of fashion clothing market. *Journal of Business Research*, *105*, 434–442. https://doi.org/https://doi.org/10.1016/j.jbusres.2019.03.029

Green, L., Miles, I., & Rutter, J. (2007). *Hidden innovation in the creative sectors*. *NESTA*.

Grin, J., Rotmans, J., & Schot, J. (2010). Introduction From Persistent Problems to System Innovations and Transitions. In J. Grin, J. Rotmans, & J. Schot (Eds.), *Transitions to Sustainable Development. New Directions in the Study of Long Term Transformative Change* (pp. 1–11). Routledge.

Gupta, S., Gwozdz, W., & Gentry, J. (2019). The Role of Style Versus Fashion Orientation on Sustainable Apparel Consumption. *Journal of Macromarketing*, *39*(2), 188–207. https://doi.org/10.1177/0276146719835283

Hays, S. (1994). Structure and Agency and the Sticky Problem of Culture. *Sociological Theory*, *12*(1), 57–72. https://doi.org/10.2307/202035

Hermwille, L. (2016). The role of narratives in socio-technical transitions—Fukushima and the energy regimes of Japan, Germany, and the United Kingdom. *Energy Research & Social Science*, *11*, 237–246. https://doi.org/https://doi.org/10.1016/j.erss.2015.11.001

Hirscher, A.-L., & Fuad-Luke, A. (2013). *Open participatory designing for an alternative fashion economy*. *Sustainable Fashion: New Approaches*. Aalto ARTS Books Helsinki, Finland.

Hirscher, A.-L., Mazzarella, F., & Fuad-Luke, A. (2019). Socializing Value Creation Through Practices of Making Clothing Differently: A Case Study of a Makershop With Diverse Locals. *Fashion Practice*, *11*(1), 53–80. https://doi.org/10.1080/17569370.2019.1565377

Hirscher, A.-L., Niinimäki, K., & Joyner Armstrong, C. M. (2018). Social manufacturing in the fashion sector: New value creation through alternative design strategies? *Journal of Cleaner Production*, *172*, 4544–4554. https://doi.org/10.1016/j.jclepro.2017.11.020

Hirscher, A. (2013). Fashion Activism Evaluation and Application of Fashion Activism Strategies to Ease Transition Towards Sustainable Consumption Behaviour. *Research Journal of Textile and Apparel*, *17*(1), 23–38. https://doi.org/https://doi.org/10.1108/RJTA-17-01-2013-B003

Hirscher, A., & Niinimäki, K. (2015). Fashion Activism through Participatory Design. Gothenburg.

Hur, E., Beverley, K., & Cassidy, T. (2013). Development of An Ideation Toolkit Supporting Sustainable Fashion Design and Consumption. *Research Journal of Textile and Apparel*, *17*(2), 89–100. https://doi.org/10.1108/RJTA-17-02-2013-B012

Huutoniemi, K., & Tapio, P. (2014). *Transdisciplinary sustainability studies: A heuristic approach*. *Transdisciplinary Sustainability Studies: A Heuristic Approach*. Taylor and Francis. https://doi.org/10.4324/9780203734834

Joore, P., & Brezet, H. (2015). A Multilevel Design Model: the mutual relationship between product-service system development and societal change processes. *Journal of Cleaner Production*, *97*, 92–105. https://doi.org/10.1016/J.JCLEPRO.2014.06.043

Kanger, L., Geels, F. W., Sovacool, B., & Schot, J. (2019). Technological diffusion as a process of societal embedding: Lessons from historical automobile transitions for future electric mobility. *Transportation Research Part D: Transport and Environment*, *71*, 47–66. https://doi.org/10.1016/j.trd.2018.11.012

Kozlowski, A., Bardecki, M., & Searcy, C. (2012). Environmental impacts in the fashion industry: A life-cycle and stakeholder framework. *Journal of Corporate Citizenship*, (45), 17–36.

Kozlowski, A., Bardecki, M., & Searcy, C. (2019). Tools for Sustainable Fashion Design: An Analysis of Their Fitness for Purpose. *Sustainability*. https://doi.org/10.3390/su11133581

Kozlowski, A., Searcy, C., & Bardecki, M. (2016). Innovation for a Sustainable Fashion Industry: A Design Focused Approach Toward the Development of New Business Models. In S. S. Muthu & M. A. Gardetti (Eds.), *Green Fashion: Volume 2* (pp. 151–169). Singapore: Springer Singapore. https://doi.org/10.1007/978-981-10-0245-8_5

Kumar, A. (2020). *Monopsony Capitalism: Power and Production in the Twilight of the Sweatshop Age*. *Development Trajectories in Global Value Chains*. Cambridge: Cambridge University Press. https://doi.org/DOI: 10.1017/9781108764810

Mazzarella, F., Mitchell, V., & Escobar-Tello, C. (2017). Crafting Sustainable Futures. The Value of the Service Designer in Activating Meaningful Social Innovation from within Textile Artisan Communities. *The Design Journal*, *20*(sup1), S2935–S2950. https://doi.org/10.1080/14606925.2017.1352803

McHattie, L.-S., Champion, K., & Broadley, C. (2018). Craft, textiles, and cultural assets in the Northern Isles: innovation from tradition in the Shetland Islands. *Island Studies Journal*, *13*(2), 39–54. https://doi.org/10.24043/isj.47

Moorhouse, D., & Moorhouse, D. (2018). Designing a sustainable brand strategy for the fashion industry. *Clothing Cultures*, *5*(1), 7–18. https://doi.org/10.1386/cc.5.1.7_2

Niinimäki, K., & Hassi, L. (2011). Emerging design strategies in sustainable production and consumption of textiles and clothing. *Journal of Cleaner Production*, *19*(16), 1876–1883. https://doi.org/10.1016/J.JCLEPRO.2011.04.020

Ozdamar Ertekin, Z., Atik, D., & Murray, J. B. (2020). The logic of sustainability: institutional transformation towards a new culture of fashion. *Journal of Marketing Management*, *36*(15–16), 1447–1480. https://doi.org/10.1080/0267257X.2020.1795429

Peters, G., Li, M., & Lenzen, M. (2021). The need to decelerate fast fashion in a hot climate - A global sustainability perspective on the garment industry. *Journal of Cleaner Production*, *295*, 126390. https://doi.org/https://doi.org/10.1016/j.jclepro.2021.126390

Pohl, C. (2014). From complexity to solvability: The praxeology of transdisciplinary research. In *Transdisciplinary Sustainability Studies: A Heuristic Approach* (pp. 103–118). Taylor and Francis. https://doi.org/10.4324/9780203734834-15

Rosenbloom, D., Berton, H., & Meadowcroft, J. (2016). Framing the sun: A discursive approach to understanding multi-dimensional interactions within socio-technical transitions through the case of solar electricity in Ontario, Canada. *Research Policy*, *45*(6), 1275–1290. https://doi.org/https://doi.org/10.1016/j.respol.2016.03.012

Šajn, N. (2019). *Environmental impact of the textile and clothing industry What consumers need to know*. Retrieved from http://www.europarl.europa.eu/RegData/etudes/BRIE/2019/633143/EPRS_BRI(2019)633143_EN.pdf

Scheffer, M. (2012). *In-depth assessment of the situation of the T&C sector in the EU and prospects. Task 7: Synthesis report for the European textile and clothing sector*. Retrieved from http://ec.europa.eu/DocsRoom/documents/10482/attachments/1/translations

Scott, A. J. (2006). The Changing Global Geography of Low-Technology, Labor-Intensive Industry: Clothing, Footwear, and Furniture. *World Development*, *34*(9), 1517–1536. https://doi.org/10.1016/J.WORLDDEV.2006.01.003

Senthil Kumar, P., Yaashikaa, P. R., & Femina Carolin, C. (2021). Sustainability in Textile Design. In S. S. Muthu & M. Angel Gardetti (Eds.), *Sustainable Design in Textiles and Fashion* (pp. 39–51). Singapore: Springer Singapore. https://doi.org/10.1007/978-981-16-2466-7_3

Soini, K., & Dessein, J. (2016). Culture-Sustainability Relation: Towards a Conceptual Framework. *Sustainability*. https://doi.org/10.3390/su8020167

Spillman, L. (1996). How are structures meaningful? Cultural sociology and theories of social structure. *Humboldt Journal of Social Relations*, *22*(2), 31–45. Retrieved from http://www.jstor.org/stable/23263030

Stoneman, P. (2010). *Soft innovation: economics, product aesthetics, and the creative industries*. Oxford University Press.

Storey, J. (2005). The Politics of Signification.

Taplin, I. M. (2006). Restructuring and reconfiguration. *European Business Review*, *18*(3), 172–186. https://doi.org/10.1108/09555340610663719

The Fashion Practice Collective. (2014). *The Fashion Condition*. *Fashion Retailing*. New York. https://doi.org/10.5040/9781501309076.ch-004

Thomas, K. (2020). Cultures of Sustainability in the Fashion Industry. *Fashion Theory*, *24*(5), 715–742. https://doi.org/10.1080/1362704X.2018.1532737

Tischner, U. (2008). Design for (social) sustainability and radical change. In A. Tukker, M. Charter, & C. Vezzoli (Eds.), *System Innovation for Sustainability 1: Perspectives on Radical Changes to Sust* (pp. 159–177). Routledge. https://doi.org/10.9774/gleaf.978-1-907643-36-1_10

Torres, A. L., & Gardetti, M. A. (2013). Sustainability in Fashion and Textiles: Values, Designs, Production and Consumption, *44*(0), 1–17.

Vezzoli, C., Ceschin, F., Osanjo, L., M'Rithaa, M. K., Moalosi, R., Nakazibwe, V., & Diehl, J. C. (2018). Design for Sustainability: An Introduction (pp. 103–124). Springer, Cham. https://doi.org/10.1007/978-3-319-70223-0_5

Voß, J.-P. (2010). Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy*, *39*(4), 435–448. https://doi.org/10.1016/J.RESPOL.2010.01.023

Vuletich, C. (2015). *Transitionary textiles: a craft-based journey of textile design practice towards new values and roles for a sustainable fashion industry* (dissertation). ProQuest Dissertations Publishing.

Wolff, J. (1999). Cultural studies and the sociology of culture. Retrieved from http://hdl.handle.net/1802/973

Technological Innovation System in Agribusiness: Motors and Evolution

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Abstract. This research aimed to analyze the evolution and interaction over time of the functions of a technological innovation system (TIS) based on the concept of an innovation motor. A case study of the innovative system associated with the production of cage-free pullets for laying eggs in Pelotas/RS was developed. The results corroborate the adequacy of functions and motors as an appropriate theoretical approach in agribusiness. The motors proposed by the TIS approach evolve sequentially and are associated with the mechanisms of cumulative causation. The results of the case study identified two new functions: analysis of the chain as a whole and coordination of the actors involved in the system, as well as the presence of tipping points at the beginning of each motor. The main limitation is the absence of a greater detailing of the market motor in discussions on the evolution of the motors and functions of the TIS Cage-Free Pelotas. Practical implications include innovation motors as a new guiding approach for participatory innovation initiatives in rural areas. Originality is the application of the approach in agribusiness, the proposition of two new functions for the analysis of motors, and the inclusion of the concept of tipping points as an activation trigger in the evolution between motors.

Keywords: Technological Innovation System; Agribusiness; Sustainability; Innovation Motors; Tipping Points.

1 Introduction

Criticisms that the linear method of technological development is flawed, coupled with the demand for sustainable agriculture, have encouraged scientists to better consider the complex context in which the technologies have been applied (Lamers; Schut; Klerkx & van Asten, 2017). These conclusions are reached because when analyzing research organizations, it is evident that it is difficult to implement new technologies developed with a focus on sustainability (Planko; Cramer; Chappin & Hekkert, 2016).

The theoretical approach called technological innovation systems (TIS) has received considerable attention in recent years as a reference for the study of emerging technologies, such as technologies focused on sustainability (Kukk; Moors & Hekkert, 2015). The TIS approach has been considered adequate to explore how organizations can encourage the creation of supply chains and increase the chances of successful implementation, succeeded by new technology available to society (Bergek, A.; Jacobsson, S.; Carlsson, B.; Lindmark, S. & Rickne, A, 2008).

Several studies have been conducted, for example, on technologies associated with biotechnology, precision agriculture (Eastwood; Klerkx & Nettle, 2017; Hall, 2005; Klerkx; Van Mierlo & Leeuwis, 2012), and sustainable agricultural systems (Lamers *et al*., 2017).

A technological innovation system (TIS) can be defined as a “set of actors and institutions in networks that interact in a technological field and/or new product” (Markard; Raven & Truffer, 2012). A TIS can also be defined as an analytical construct incorporating subsystems of the innovation system until it is disconnected to guide decision-makers (Bergek et al., 2008).

The concepts of TIS are based on the idea that the determinants of innovation and technological change do not lie only in research organizations but are also located in the broader innovation system that supports and restricts the activities of these organizations (Bergek et al., 2008). Thus, a TIS is generally analyzed in terms of seven functions. System functions are considered classes of processes that contribute to the development, diffusion, and use of technological innovations (Hekkert; Suurs; Negro; Kuhlmann & Smits, 2007). Technological innovation systems are the most important processes in building an innovation system; namely: F1 - entrepreneurial experimentation; F2: knowledge development; F3: dissemination of knowledge; F4: research orientation; F5: market formation; F6: resource mobilization; and F7: creation of legitimacy. The list of seven system functions was established based on a review of many years of literature on system innovation (Hekkert et al., 2007). However, more recently, a set of three other functions has been considered fundamental in the evolution of a technological innovation system: coordination (Markard; Geels & Raven, 2020; Planko et al., 2016), sociocultural changes (Planko et al., 2016; Markard et al., 2020), and the analysis of the system as a whole (Markard et al., 2020).

When the approach to technological innovation systems is analyzed, one criticism of the approach is that it is static and pays little attention to the evolution of system functions (Lachman, 2013; Planko et al., 2016). In addition, little attention has been paid to how the interaction between functions occurs, which is included and excluded along the innovation trajectory (Lamers et al., 2017).

The concept of an innovation motor (Suurs & Hekkert, 2012; Suurs, 2009) overcomes criticisms of the TIS approach by emphasizing the evolution of functions and their relationships over time. The concept of an innovation motor is a set of hypotheses on how and which functions influence each other at different stages of the evolution of a

technological innovation system, forming a typology called innovation motors (Suurs & Hekkert, 2012; Suurs, 2009).
The concept of an innovation motor, however, has not been widely understood and developed in the innovation systems literature (Köhler; Raven & Walrave, 2020), with the exception of the work of (Walrave & Raven, 2016). This gap represents an opportunity, given the need to better understand the dynamics of a TIS, especially the evolution of functions and their interactions that support the evolution of TIS, as the understanding of the relationships between functions over time is still limited (Köhler et al., 2020), especially in rural environments, which has not been found in previous studies.
Considering the need to advance the understanding of the dynamics of a technological innovation system, the following research question was established: How do the functions and interactions between them evolve in a system of technological innovation in agribusiness? Therefore, it was established as a general objective to analyze the evolution and interaction of the functions over time, from the concept of an innovation motor in the rural environment, and with a focus on sustainability. To answer the proposed research question, a case study of an innovative system associated with the production of cage-free pullets for egg laying was developed. This technology has been developed worldwide and in the region of Pelotas-RS by Embrapa Clima Temperado-Pelotas/RS with a view to concerns about animal welfare and sustainability.

2 Technological Innovation Systems

2.1 Key Functions of Technological Innovation Systems

The functions of innovation systems are considered classes of processes that contribute to the development, diffusion, and use of technological innovation (Hekkert et al., 2007). These are dynamic processes that occur between the structural components (actors, networks, and institutions) of the system. Each function contributes to building a favorable system around the new technology (Musiolik & Markard, 2011). The seven functions traditionally discussed in the literature are discussed below.
Function 1: Entrepreneurial experiments. Entrepreneurs are key in a TIS because they convert potential new ideas into business opportunities (Hekkert et al., 2007; Planko; Cramer; Hekkert & Chappin, 2017). These entrepreneurs can be new businesses or established firms that want to diversify into new technologies. By testing new technologies in the market, social learning processes can be activated. This makes it possible to gather new information on the reactions of consumers, governments, competitors, and suppliers (Hekkert et al., 2007; Planko et al., 2017).

Function 2: Knowledge development. Learning activities, such as research, development, and learning in a practical context, are fundamental to any innovation process. Knowledge cannot only be acquired about new technology but also about markets, networks, and users (Bergek et al., 2008; Hekkert et al., 2007; Planko et al., 2017).

Function 3: Disseminating Knowledge. Conferences, workshops, and alliances encourage knowledge exchanges. This is important not only for the exchange of specific R&D knowledge but also for the exchange of knowledge between the government, business, and the market (Hekkert & Negro, 2009; Planko et al., 2017).

Function 4: Research orientation. This key process summarizes all activities and events that convince actors to enter or invest in a TIS. A positive expectation regarding technology development is the main aspect here. This expectation may be based on changes in attitudes, entry prices, regulations, and policies (Bergek et al., 2008; Hekkert et al., 2007; Planko et al., 2017).

Function 5: Market formation. We can say that the new sustainability technologies have difficulty competing with dominant technologies. It is necessary to create temporarily protected market niches for technology to develop and gain a market share. Such niches can have favorable tax regimes, guaranteed consumption quotas, environmental regulations, and public contracting policies (Bergek et al., 2008; Hekkert et al., 2007; Planko et al., 2017).

Function 6: Resource mobilization. This key process pertains to the resources required for a TIS to function properly. Financial and human resources must be mobilized to enable the construction of an innovation system, and complementary resources must be developed, such as complementary products, services, and network infrastructure (Bergek et al., 2008; Hekkert et al., 2007; Planko et al., 2017).

Function 7: Creating legitimacy. Sustainability-focused innovations often struggle to overcome the inertia caused by the current production system, which is often reluctant to change. Therefore, coalitions and lobbying in defense of the new technology with a view to winning resources and favorable tax regimes and putting new technology on the policy agenda (Hekkert et al., 2007; Planko et al., 2017).

2.2 New Key Functions Associated with TIS

Three new key functions for developing a technological innovation system have been suggested: coordination (Markard et al., 2020; Planko et al., 2016), sociocultural changes (Planko et al., 2016; Markard et al., 2016; 2020), and the analysis of the system as a whole (Markard et al., 2020). The three new function proposals are discussed below.

Coordination Function (F8): the effort coordination function is seen as a function that contributes to the acceleration of the construction of a TIS because the diffusion of innovations usually requires alignments between several policies (Markard et al., 2020;

Planko et al., 2016). However, a set of activities is considered important in this effort to coordinate a TIS. (Planko et al., 2016) highlighted seven other activities. The first two were creating a shared vision and setting common goals among the TIS participants. The third activity involves the standardization of products and services. Standardization is important for reducing production costs and building a reliable system, enabling buyers and consumers to choose among available brands (Planko et al., 2016). The fourth activity is the creation of open innovation platforms within the TIS with the aim of increasing the speed of innovation of complementary products (Planko et al., 2016). Finally, the last three activities are system orchestration, which refers to the management and alignment of the efforts of individual participants, and requires the activity of defining the functions of TIS participants in order to create the resources required to compete with the regime. Finally, the last activity is the creation of transparency, which is important because it can avoid overlapping functions and resources by optimizing the TIS (Planko et al., 2016).

Function of Sociocultural Change (F9): Innovations, especially those focused on sustainability, need to be well rooted in society (Markard et al., 2020; Planko et al., 2016). This means that entrepreneurs need to strive for desired changes to take place in consumer decision-making. Therefore, these entrepreneurs need to change their ingrained values and norms in favor of new technology. A set of activities is associated with sociocultural change. In relation to the entrepreneurs' businesses, they themselves must induce a more collaborative action among their employees; induce changes in consumer values; and work in the educational system with a view to training professionals with skills to work in the new technology (Planko et al., 2016). Markard et al. (2020) highlight that policymakers can change consumer behavior by providing more information about new technology, creating performance standards for products, reducing fees, and creating subsidies that aim to encourage the adoption of new sustainable technology.

Changes in the function of the system as a whole (F10): Markard et al. (2020) highlighted this function by stating that innovations focused on sustainability fail to align the system as a whole. For this to occur, two critical issues need to be overcome: (i) the need to foster complementary interactions between multiple innovations and (ii) the need to promote changes in the system's architecture. In agribusiness, the need for a global vision is not new and can be seen in the production chain concept. According to Batalha and Silva (2008, p. 32), the definition of a production chain starts with the identification of a final product "[...] after this identification, it is necessary to chain, from downstream to upstream, the various operations technical, commercial and logistical requirements for its production". Through the application of the production chain concept, one can see the complexity of the production process, which implies aligning and innovating the various links of the production chain as a whole, with a view to the success of the chain that one wants to promote.

2.3 Innovation Motors

Suurs (2009) highlights that the discussion on innovation motors originates in studies on organizational change, more specifically in the notion of motors employed by (Poole; Van de Ven; Dooley & Holmes, 2000). Suurs and Hekkert (2012) and Suurs, Hekkert, and Smits (2009) studied the notion of innovation motors in technological innovation systems and identified four types of combinations of functions. Each of these four motors is described as follows.

The first motor is driven by science and technology (Suurs & Hekkert, 2012; Suurs, 2009). This motor refers to a pattern in the innovation system in which the development of scientific knowledge and diffusion is central, supported by research projects and policies (Walrave & Raven, 2016). Motor function is initiated by a common activation trigger, which is a social and environmental problem (Suurs & Hekkert, 2012; Suurs, 2009). The production and dissemination of scientific knowledge shape the first experiments and some entrepreneurial activities, which may increase or decrease depending on whether the results confirm initial expectations (Walrave & Raven, 2016). This motor is dominated by knowledge development (F2), knowledge dissemination (F3), research guidance (F4), and resource mobilization (F6) functions. The role of entrepreneurial activities (F1) is also important in the motor engine that drives science and technology (Suurs & Hekkert, 2012; Suurs et al., 2009).

The second motor is called the entrepreneurial motor. This refers to a pattern of the innovation system in which the central dynamic is constituted by an increase in active entrepreneurs in the innovation system (Markard et al., 2020). Suurs and Hekkert (2012), Suurs (2009), and Walrave and Raven (2016) explain that in this motor, the start of a vicious circle of technological development is the entrepreneurs who lobby (F7) for better economic conditions, and thus make technological development possible. Suurs et al. (2009) explain that the entrepreneur's role is to translate knowledge into business opportunities and, eventually, innovations. Suurs and Hekkert (2012) clarify that, in some cases, this dynamic is strengthened by niche market activities (F5). These involve small markets that are usually not developed within TIS itself (Suurs & Hekkert, 2012; Walrave & Raven, 2016). The periphery of this motor comprises motor connections driven by science and technology (Suurs & Hekkert, 2012).

The third motor is called the system construction (Suurs & Hekkert, 2012; Suurs, 2009). This refers to a pattern of the innovation system characterized by an increase in system actors acting in networks, infrastructural development, and attempts to reconfigure institutions (Walrave & Raven, 2016). The network starts to attract broader social support, for example, for the institutionalization of new incentive policies or the construction of physical infrastructure. The motor comprises entrepreneurial motor relationships, but with more additions and emphasis on creating legitimacy (F7), market formation (F5), and research orientation (F4). The valley of death in the TIS evolution process (Suurs & Hekkert, 2012; Walrave & Raven, 2016).

The fourth is the market motor (Suurs & Hekkert, 2012; Suurs, 2009). This refers to a pattern of the innovation system in which there is substantial market demand that is sufficient to keep all entrepreneurs associated with TIS (Walrave & Raven, 2016). TIS is already legitimized by social and political actors and is no longer explicitly questioned. In terms of functions, all functions are important, but creating legitimacy is less important (Suurs & Hekkert, 2012; Walrave & Raven, 2016).

3 Methodology

The research strategy was classified as a qualitative study of single-case analysis (Yin, 2017). A qualitative case study is characterized by the search to know in depth a certain situation that is supposed to be unique (Yin, 2017).

This case was defined as an innovation system associated with the cage-free chicken production process. The spatial domain was defined as the starting point for the city of Pelotas RS and the actors and institutions in other cities with interactions based on it. Having decided on the case and spatial domains, the next step was to identify the structural components of the system. These included not only companies but also rural producers and some of their suppliers, universities, and development institutes, as well as public bodies and organizations with common interests. The snowball technique was used to identify the actors in the sense that once one of the actors was identified, he was asked about other actors who could participate in the TIS. This procedure is supported by Bergek et al. (2008), who state that, given the large uncertainties involved when the analysis concerns an emerging TIS, a definitive focus may be difficult to choose and may have to change over time.

A script was used for data collection that guided the interviews, document analysis, and participant observation. The interview and document analysis scripts are based on the seven functions of Hekkert et al. (2007), with the addition of the three functions proposed by Planko et al. (2016) and Markard et al. (2020).

Four interviews were conducted with key people:

Responder 1 - Researcher II in Agroecology at the Brazilian Agricultural Research Corporation (EMBRAPA), focusing on colonial and organic poultry farming and agroecology.

Respondent 2 - Veterinary Doctor, Poultry Professor of Technical Education at the Federal University of Pelotas/IFSUL.

Respondent 3 - Regional Manager of the Technical Assistance and Rural Extension Company - Emater/Ascar.

Respondent 4 - Extensionist at Emater since 2012–Lecturer in the colonial aviculture course.

The documents considered in the data collection comprised a thesis, five official government documents, three minutes of a network meeting involving TIS members, a law, and 11 news articles from local newspapers and media. In addition, participant observation was carried out in 12 activities involving the analyzed TIS. Data were collected for 2019 and 2020.

For the analysis of the collected data, the procedural method or sequence analysis (Abbott, 1995) suggested by Suurs and Hekkert (2012) was used. The procedural method conceptualizes development and change processes as sequences of events and explains the products of a process as the result of an order of events (Abbott, 1995). Events are central elements of what subjects do or happen to them (Abbott, 1995). Hekkert et al. (2007) recommend that all mapped events be allocated to functions via a schema. This allowed the researcher to verify the validity of these functions. Forty-one events were identified and classified along the TIS trajectory (1999-2020).

To conduct the study, we followed the research judgment criteria proposed by Yin (2017). Regarding the quality of the results, multiple data sources were used, such as interviews, documents, legislation, and participant observation (Yin, 2017). Regarding internal validity, the observed results were compared with the existing theory regarding the functions initially, the innovation motors, and the confidentiality of the collected data (Yin, 2017). External validity is determined by comparing the results obtained and interpreted during the research with the co-author of the research, who we believe has more comprehensive knowledge about the case studied and is an expert in the theoretical approach of technological innovation systems (Yin, 2017). The reliability of this research is supported by the data analysis script composed of theoretical categories (10 functions of the dynamics of a TIS) reviewed in Sections 2.1 and 2.2 (Yin, 2017).

4 Results and discussions

4.1 Description of the Evolution of the Motors and Functions of the TIS Cage-Free Pelotas

In this section, the evolution of innovative functions and motors is described based on the events identified and classified according to the ten functions reviewed in Sections 2.2 and 2.3. Three motors are identified. The TIS Cage-Free Pelotas (Phase I) began with the creation of the Science and Technology motor in 1999, and subsequently by the Entrepreneurship Motors (Phase II in 2017) and by the System Construction motor (Phase III in 2019, Figure 1). Each of these motors is described as follows.

Phase I, the creation of the Science and Technology Motor Company, was characterized by the presence of the first tipping point (TP1), which was a social demand to create income for a local community of rural producers in extreme poverty.

Based on this demand, EMBRAPA created a research project (F4) to develop technology for the creation and management of free birds for these vulnerable families. From the project onwards, knowledge development (F2) began with the installation of demonstration units to validate the previously designed creation model. The results of the demonstration units indicated the need for reorienting research (F4), including research on the preparation of low-cost poultry feed, as well as for the automation of processes within the poultry house, which culminated in knowledge development activities (F2). The installation of demonstration units and new research projects contributed to the creation of a producer-training course (dissemination of knowledge, F3). The entrepreneurial experimentation function (F1) was also present at this stage, with the formalization of the first production establishment in compliance with sanitary, environmental, and fiscal rules for this type of production.

Phase II of the creation of the Entrepreneurship Motor began with a second tipping point that was characterized by the need for local rural producers to generate more income in their businesses, especially those producers who had idle breeding facilities (poultry houses) due to the stoppage of the activities of the local cooperative, which was produced in the traditional system (TP2), fostering several initiatives of entrepreneurial experimentation (F1) in the technology of production of cage-free poultry eggs. Subsequently, these entrepreneurs began to lobby the local government agency with a view to creating legitimacy (F7) of the new technology, placing their ventures on the local government’s agenda with a view to solving their identified problems and resources that favor production. In response to the lobbying carried out by the producers, the local government agency started a series of analysis and negotiation actions with the aim of structuring the chain as a whole (F10), such as an agreement for a local slaughterhouse to dispose off poultry, the promotion of one of the producers to carry out the step of rearing the pullets, and the installation of a feed mill.

Phase III, the creation of the system construction motor, also started with a tipping point (TP3), which was interpreted as the local government’s need for strategies for the development of the cage-free egg production chain. Based on this search, it was decided to create a network involving producers and public and private organizations led by the local government, with a view to coordinating actions (F8) with a focus on promoting technology. Once the network was created, two new functions began to be developed with TIS participants: market formation (F5) and resource mobilization (F6). Market creation actions involved holding meetings with local traders to attract new customers and meetings with managers of public organizations with the objective of creating specific demands on the part of these organizations. Resource mobilization actions involve the inclusion of new actors with different functions in the newly created network.

In addition to activities associated with market formation (F5) and resource mobilization (F6), the network also started to interact with the other two motors: entrepreneurship and science and technology.
The interaction with the network's entrepreneurship motor expanded the actions to create legitimacy (F7) through the dissemination of the creation of the network itself and the importance of the new technology for the production of cage-free pullet eggs, the creation of a law by the local government to encourage entrepreneurs, publicizing the activities in local and national newspapers, and creating a logo for the network created. The actions of structuring the chain as a whole (F10) involved the continuation of actions initiated in the entrepreneurship motor as well as the development of new options to encourage the creation of a feed mill. In the Entrepreneurial Experimentation actions (F1), new projects were designed for other rural producers to enter production with new technology.
In the interaction with the science and technology motor, the network influenced the research orientation (F4), with the proposition of reactivating the lowest-cost feed research project, this time together with current producers, in actions to develop knowledge (F2), as a line of research into production costs and knowledge dissemination actions (F3), as a way to encourage producers to split the long-term training course and short-term courses on alternative food and marketing strategies. Figure 1 summarizes the described evolution of the functions and motors identified in the TIS cage-free pelotas.

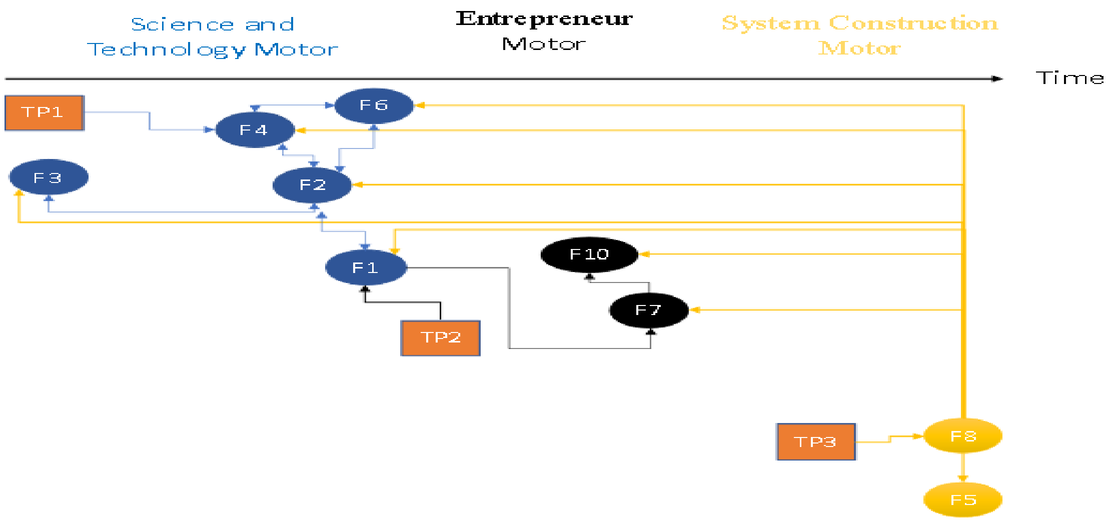

Fig. 1. Evolution of TIS Cage-Free Pelotas Functions and Motors

4.2 Discussion of the Evolution of Motors and Functions

The evolution of the TIS Cage-Free Pelotas motors and functions was organized in two stages:1) analysis of each of the motors individually: science and technology

motor, entrepreneurship motor, system construction motor; and 2) motor sequence analysis.
When comparing the description of the Science and Technology Motor of the TIS Cage-Free Pelotas, it is verified that it corroborates the description of this type of motor proposed by (Suurs & Hekkert, 2012). It appears that the motor system is dominated by knowledge development functions (F2). Dissemination of knowledge (F3), research orientation (F4), and resource mobilization (F6) (Suurs & Hekkert, 2012). The Entrepreneurial Experimentation (F1) function was incipient, with only one formalized enterprise. The market formation function (F5) was considered absent because it was restricted to the production and marketing activities of the demonstration units. Likewise, the legitimacy creation function (F7) was limited to a small set of actors' participants in this motor (Suurs & Hekkert, 2012). In addition, the new functions identified in the literature on coordination (F8), sociocultural changes (F9), and evaluation of the chain as a whole (F10) were also absent.
When comparing the description of the Entrepreneurship Motor of the TIS Cage-Free Pelotas, the results partially corroborate the proposition of Suurs and Hekkert (2012), as important differences and similarities were identified. Suurs and Hekkert (2012) define the entrepreneurship motor as similar to the science and technology motor with the addition of entrepreneurial experimentation (F1) and legitimacy creation (F7) functions. Regarding similarities, the TIS Cage-Free Pelotas in the Entrepreneurship Motor phase was characterized by many entrepreneurial experimentation initiatives (F1) associated with legitimacy creation initiatives (F7), which was also highlighted by Suurs and Hekkert (2012). Regarding the differences, the TIS Cage-Free Pelotas was characterized by the presence of the chain analysis function as a whole (F10) as a result of the lobby promoted by entrepreneurs in order to solve local problems, more specifically associated with solving the bottlenecks identified in the production chain with a view to the productive feasibility of its projects, such as a place for disposal of poultry after the end of the production cycle and feed at lower costs. The presence of the new function chain analysis as a whole (F10) corroborates the proposal by Markard *et al.* (2020) as another important function, especially in agribusiness and new technologies that transform into new businesses. In agribusiness, one can see how complex the production process is because of the multiple steps that must be articulated throughout the manufacture of any product until it reaches its final consumer.
Regarding the TIS Cage-Free Pelotas System Construction Motor, the results partially corroborate the proposition of Suurs and Hekkert (2012), as important differences and similarities were also identified here. Suurs and Hekkert (2012) defined the system construction motor as a motor in which all functions are involved, which is an important addition in relation to the two previous motors in the market formation function (F5). The similarity is that the market formation function (F5) appears as one of the functions of TIS, and this motor involves a relationship with all other functions (Suurs & Hekkert,

2012). The difference is related to the coordination function (F8), which was proposed as a key function in this motor and corroborates the proposal (Markard *et al*., 2020; Planko *et al.,* 2016). Planko *et al*. (2016) justify the need for the coordination function as they consider that many actors are involved in the building system, each with its own agenda and strategic plan; however, the system as a whole benefits most if resources are combined and if efforts are aligned. Without coordination, individual efforts can be useless (Planko *et al*., 2016).

Regarding the analysis of the sequence of the TIS Cage-Free Pelotas motors, the results partially corroborate the proposition of Suurs and Hekkert (2012), as similarities and differences were identified.

Regarding similarity, a sequence in the creation of innovative motors can be seen: science and technology motor => entrepreneurship motor => system construction motor. This result is consistent with the conclusions of Suur (2009). Suurs (2009) explains that the sequence of motors is in line with the concept of cumulative causation and that the structural conditions under which a vicious circle emerges are affected by its previous dynamics. More specifically, he explains that with each motor change, the previous structural configuration will reinforce the activities that constitute the next (motor) cycle, which can be seen in the trajectory of the TIS cage-free pelotas.

Regarding the difference, it can be seen that there is a tipping point (TP) at the beginning of each motor and not only in the science and technology motor. For the creation of the Science and Technology Motor, Suurs (2009) cited social demands for new technology as an example. However, Suurs (2009, 2012) does not emphasize these tipping points in the trajectory of TIS, nor does it provide a definition of the term. In the literature, tipping points have been defined as discontinuities in the development of a system trajectory that fundamentally changes its structure and dynamics (Mey & Lilliestam, 2020). In other words, (Mey & Lilliestam, 2020) defined a tipping point as the point that separates state A from state B of a system. We observed this phenomenon in all changes in the type of motor, as we see a conjunction composed of an entrepreneurial type of social intervention combined with a perceived context, such as an economic crisis that is internal or external to the system (Mey & Lilliestam, 2020). Our findings are also supported by the recognition of the presence of the tipping point phenomenon during the stages of the innovation process in other evolutionary studies from different areas of research, such as biophysical systems, environment-human interaction, and social systems (Mey & Lilliestam, 2020) and even in the area of innovation, but under different names (Bergek et al., 2015; Dias & Ramirez, 2020; Dias, 2011). Suurs (2009) also recognizes the possibility of tipping points in other phases by recognizing that it is important to understand that there is a possibility that TIS will not evolve into any other vicious circle if external factors are not present.

Finally, from the explanations of the sequence of motors related to cumulative causation and tipping points, it is inferred as possible explanations for the absence of the market motor in the TIS Cage-Free Pelotas. Finally, it is worth commenting on the absence of the sociocultural change function (F9), proposed by (Planko *et al*., 2016; Markard *et al.,* 2020), in none of the three motors described in the TIS Cage-Free Pelotas. As it involves changes in the mental groups of consumers and organizations (Suurs & Hekkert, 2012), this must be an important function in the market motor; for this reason, it cannot be verified.

5 Final Considerations

This study aimed to analyze the evolution of functions and the interactions between them over time in a technological innovation system (TIS) within agribusiness. Throughout the evolution of the TIS cage-free pelotas, the framework associated with the functions and motors is suitable for the analysis of the evolution of the TIS, given that the presence of three motors was found:

Initially (Phase I), by the creation of the Science and Technology motor, started in 1999, and subsequently by the Entrepreneurship Motors (Phase II), started in 2017; and by the motor construction motor system (Phase III), started in 2019, and by the absence of the motor market (see Figure 1 in Section 4.1).

As the main theoretical contributions, the literature on the analysis of the evolution of technological innovation systems in the research stands out.

The adequacy of functions and motors (Hekkert et al., 2007; Suurs, 2009; Suurs & Hekkert, 2012) is an appropriate instrument for the analysis of technological innovation systems in agribusiness.

The Entrepreneurship Motor was characterized by the presence of the chain analysis function as a whole (F10) as a result of the lobbying promoted by entrepreneurs to solve local problems, more specifically associated with the solution of the bottlenecks identified in the production chain with a view to the productive feasibility of its projects.

The system construction motor and the presence of the coordination function (F8) as a key function in this motor corroborated the proposal (Planko et al., 2016; Markard et al., 2020), and this is a key function for the analysis of TIS.

The motors proposed by Suurs (2009) and Suurs and Hekkert (2012) evolve sequentially in association with the mechanisms of cumulative causation.

The influence of the tipping points at the start of each of the identified motors was verified (Mey & Lilliestam, 2020).

As an empirical contribution to the rural environment, knowledge about the evolution of functions and the interactions between them over time can contribute to the solution of one of the main problems associated with participatory innovation initiatives in rural areas, as these focus exclusively on the rural community level. It is known that these groups often find it difficult to overcome structural barriers to innovation that require interventions from higher levels of the system, such as poor access to extension services, land, credit, high input quality, and markets (Lamers et al., 2017).

For future research, it is worth highlighting the need to improve and test the results found here for other technological innovation systems in agribusiness. It is also suggested to better understand the roles of different actors, especially key actors that are difficult to replace, feedback circles, and cumulative effects. Finally, the main limitation of the research may be the absence of a market motor, but it is justified by the current stage of development of the researched TIS; however, it is noteworthy that it is difficult to identify a priori the stage of the TIS in the research process.

References

Abbott, A. (1995). Sequence Analysis: New Methods For Old Ideas. Annual review of sociology, 21(1), pp. 93-113.

Batalha, M. O.; Silva, A. L. D. (2008). Gestão Agroindustrial. São Paulo: Atlas.

Bergek, A.; Jacobsson, S.; Carlsson, B.; Lindmark, S.; Rickne, A. (2008). Analyzing The Functional Dynamics Of Technological Innovation Systems: A Scheme Of Analysis. Research Policy, 37(3), pp. 407-429. DOI:10.1016/j.respol.2007.12.003

Bergek, A.; Hekkert, M.; Jacobsson, S.; Markard, J.; Sandén, B.; Truffer, B. (2015). Technological Innovation Systems In Contexts: Conceptualizing Contextual Structures And Interaction Dynamics. Environmental Innovation and Societal Transitions, 16, pp. 51-64. DOIi:https://doi.org/10.1016/j.eist.2015.07.003

Dias, M. F. P. (2011). Dinâmica De Configuração De Regras Para Inovação: Um Olhar Complexo E Interteórico Numa Organização De Pesquisa Agrícola Do Agronegócio Orizícola Do Rio Grande Do Sul. Tese de doutorado. Universidade Federal do Rio Grande do Sul, Porto Alegre, RS. Available at: http://hdl.handle.net/10183/30465. Access on: November 17, 2021

Dias, M.; Ramirez, M. (2020). Niche Evolution, External Circumstances, And Network Transformation: From Butiá Technical Niche To Butiá Socio-Technical Niche. Revista Brasileira de Inovação, 19, pp. 1-26. DOI: https://doi.org/10.20396/rbi.v19i0.8657550.

Eastwood, C.; Klerkx, L.; Nettle, R. (2017). Dynamics And Distribution Of Public And Private Research And Extension Roles For Technological Innovation And Diffusion: Case Studies Of The Implementation And Adaptation Of Precision Farming Technologies. Journal of Rural Studies, 49, pp. 1-12.

Hall, A. (2005). Capacity Development For Agricultural Biotechnology In Developing Countries: An Innovation Systems View Of What It Is And How To Develop It. Journal of international development, 17(5), pp. 611-630.

Hekkert, M. P.; Negro, S. O. (2009). Functions Of Innovation Systems As A Framework To Understand Sustainable Technological Change: Empirical Evidence For Earlier Claims. Technological Forecasting and Social Change, 76(4), pp. 584-594.

Hekkert, M. P.; Suurs, R. A. A.; Negro, S. O.; Kuhlmann, S.; Smits, R. E. H. M. (2007). Functions Of Innovation Systems: A New Approach For Analysing Technological Change. Technological Forecasting and Social Change, 74(4), pp. 413-432. DOI:http://dx.doi.org/10.1016/j.techfore.2006.03.002

Klerkx, L.; Van Mierlo, B; Leeuwis, C. (2012). Evolution Of Systems Approaches To Agricultural Innovation: Concepts, Analysis And Interventions. Farming Systems Research into the 21st century: The new dynamic, pp. 457-483. D0I:10.1007/978-94-007-4503-2_20

Köhler, J.; Raven, R.; Walrave, B. (2020). Advancing the analysis of technological innovation systems dynamics: Introduction to the special issue. Technological Forecasting and Social Change, 158, 120040. DOI:https://doi.org/10.1016/j.techfore.2020.120040

Kukk, P., Moors, E. H. M., and Hekkert, M. P. (2015). The Complexities In System Building Strategies — The Case Of Personalized Cancer Medicines In England. Technological Forecasting and Social Change, 98, PP. 47-59. DOI:https://doi.org/10.1016/j.techfore.2015.05.019

Lachman, D. A. (2013). A Survey And Review Of Approaches To Study Transitions. Energy Policy, 58, pp. 269-276. DOI:10.1016/j.enpol.2013.03.013

Lamers, D.; Schut, M.; Klerkx, L.; van Asten, P. (2017). Compositional Dynamics Of Multilevel Innovation Platforms In Agricultural Research For Development. Science and Public Policy, 44(6), pp. 739-752. DOI:10.1093/scipol/scx009

Markard, J., Raven, R., and Truffer, B. (2012). Sustainability Transitions: An Emerging Field Of Research And Its Prospects. Research Policy, 41(6), pp. 955-967. DOI:10.1016/j.respol.2012.02.013

Markard, J.; Geels, F. W.; and Raven, R. (2020). Challenges In The Acceleration Of Sustainability Transitions. Environmental Research Letters, 15(8). DOI:https://doi.org/10.3929/ethz-b-000439169

Mey, F. & Lilliestam, J. (2020). Deliverable 3.1: Policy And Governance Perspectives On Tipping Points-A Literature Review And Analytical Framework. Available at: <https://www.iass-potsdam.de/en/output/publications/2020/deliverable-31-policy-and-governance-perspectives-tipping-points>. Access on 17 nov. 2021.

Musiolik, J. & Markard, J. (2011). Creating And Shaping Innovation Systems: Formal Networks In The Innovation System For Stationary Fuel Cells In Germany. Energy Policy, 39(4), pp. 1909-1922.

Planko, J.; Cramer, J. M.; Chappin, M. M.; Hekkert, M. P. (2016). Strategic collective system building to commercialize sustainability innovations. Journal of cleaner production, 112, pp. 2328-2341.

Planko, J.; Cramer, J.; Hekkert, M. P.; Chappin, M. M. H. (2017). Combining The Technological Innovation Systems Framework With The Entrepreneurs' Perspective On Innovation. Technology Analysis and Strategic Management, 29(6), pp. 614-625. DOI:10.1080/09537325.2016.1220515.

Poole, M. S.; Van de Ven, A. H.; Dooley, K.; Holmes, M. E. (2000). Organizational Change And Innovation Processes: Theory And Methods For Research. Oxford: Oxford University Press.

Suurs, R. A. A. (2009). Motors Of Sustainable Innovation: Towards A Theory On The Dynamics Of Technological Innovation Systems. Ulrtecht: Utrecht University.

Suurs, R. A.; Hekkert, M. P.; Smits, R. E. (2009). Understanding The Build-Up Of A Technological Innovation System Around Hydrogen And Fuel Cell Technologies. International Journal of Hydrogen Energy, 34(24), pp. 9639-9654.

Suurs, R.; Hekkert, M. (2012). Governing the Energy Transition. [S.l.]: Routledge. pp. 163-190. Available at: https://www.taylorfrancis.com/chapters/edit/10.4324/9780203126523-14/motors-sustainable-innovation-understanding-transitions-technological-innovation-system-perspective-roald-suurs-marko-hekkert-roald-suurs-marko-hekkert. Acess on 16 june 2021.

Walrave, B.; Raven, R. (2016). Modelling The Dynamics Of Technological Innovation Systems. Research Policy, 45(9), pp.1833-1844.

Yin, R. K. (2017). Case Study Research And Applications: Design And Methods. Sage

The Gendered Analog-Digital Divide in Virtual Academia

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Abstract. During the Covid-19 pandemic, in times of worldwide lockdowns, academic careers were impacted in a gendered way (Gabster et al., 2020): Existing gender inequalities have increased (Oleschuk, 2020) and female academics, especially early career researchers, have conducted less research compared to men (Viglione, 2020; Amano-Patiño et al., 2020). Also, women's submissions to peer reviewed journals dropped radically. One might argue that the pandemic is over, and that academic life is back to normal, leaving us with the benefits of improved tools and practices for virtual collaboration. However, virtual academia risks increasing inequalities, an effect we will refer to as the analogue-digital divide. These risks affect especially researchers at the beginning of their career, and those who contribute to a greater extent to academic and family care work, which are mainly women. In this paper, we reflect and consolidate the findings of six projects with partners across Europe and two universities which analysed the lasting effects of the pandemic from the perspectives of researchers at different career stages, service staff, as well as decision makers in boards and juries. We conclude that strategies and measures developed before the Covid-19 pandemic do not consider virtual academia sufficiently. We thus suggest how to counteract the analog-digital divide with requests of funding organisations and implemented by research processing organisations in their gender equality plans (GEPs).

1 Introduction

The Covid-19 pandemic has accelerated the impact of digitalisation on the academic system that can be considered as the result of the interplay of various actors, linking and shaping the institutions in which they perform multiple roles depending on their career stage. For example, well established researchers become members of boards, panels, and juries, which among others decide on strategies and measures dedicated to gender, diversity, equality and inclusion. As supervisors they are expected to support students and **early stage researchers (ESR)**[2] who rely on feedback, guidance to build their academic reputation. Building personal networks for future collaborations, is thereby crucial to become a recognized member of academia which has been recognized for being highly gendered (van den Brink and Benschop, 2011).

To improve gender equality in academia **Research funding institutions (RFOs)** have strategies and dedicated resources and **research performing organisations (RPOs)** have set measures accordingly. The process of improving gender equality is supported by change agents[3] who are dedicated to providing an environment that lets ESR develop their talents and supporting the implementation of measures for gender and diversity equality.

In this respect it must be added that available data and studies of the academic system lack a non-binary differentiation of gender. Additionally, European equality strategies and funding requirements still refer to gender in a binary way, especially when asking for indicators. The European SHE FIGURES (2018, 2021), an important reference guideline, represent the available data and the approach (Kleinberger-Pierer, Pohn-Weidinger and Grasenick, 2020). Thus, improving gender equality in the academic system mainly refers to the representation of female academics.

When analysing the impacts of the Covid 19 pandemic on measures dedicated to support gender equality, the present paper too, often relies on data presented in a binary way in the scientific literature and project reports. Our analysis is further based on surveys, interviews, focus groups, and workshops with different actors of the academic system engaged in several projects (cf. Figure 1). By identifying similarities and differences in the conclusions that have been drawn by the actors involved, we demonstrate that well-known mechanisms of gender inequality referring to care work and access to analog and digital resources are still at work and have been reinforced in virtual academia. These effects are referred to in this paper as analog-digital divide.

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[2] The European Commission (https://ec.europa.eu/info/funding-tenders/) defines Early Stage Researchers (ESR) as researchers who have not been awarded a doctoral degree. They must be in the first 4 years of their research career (full-time equivalent research experience calculated from the date they qualified by a master or similar degree). For the paper we agreed to expand the definition to 2 years after the doctoral degree.

[3] Change agents are people in organisations who are (formally) responsible or engaged for initiating, implementing and coordinating change in form of daily efforts, projects or full programs – here with regard to gender equality. Thus, they are feminist agents of transformation and cultural change, effecting change to the gendered status quo of their own institutions (Parsons and Priola, 2013; Meyerson and Tompkins, 2007). In this paper we include researchers, service staff and decision makers who are committed and contribute their personal resources to enhance gender equality as informal change agents.

Questions asked focused on the impact of the Covid-19 pandemic on workload and career development, the perceived challenges as well as potential benefits of virtual academia and recommendations for gender and diversity equality.

Figure 1: Overview on contributing projects and the role of authors. Source: own illustration

Project Acronym	Main Focus, Website	Runtime	Partner Institutions	Countries	Role of Authors
ACT	Communities of Practice for Accelerating Gender Equality and Institutional Change in Research and Innovation https://act-on-gender.eu	2018-2021	17 RPOs, RFOs	26 (Europe)	external evaluators
Arqus	Action line "Research Support and ESR Development" (Pre- and Postdocs, established researchers) https://www.arqus-alliance.eu/	2019-2022	7 universities	7 (AT, IT, …)	partner (implementation, monitoring)
CHANGE	CHAlleNging Gender (In)Equality in science and research" https://www.change-h2020.eu	2018-2022	6 RPOs	5 (AT, BE, DE, IL, PT, SI, SK)	partner (gender expert)
GenderNetz	Gender bias of women's career paths in engineering and information technology through informal support relationships and networks (pre- and postdocs, established researchers) https://gendernetz.de	2018-2021	11 9 RPOs, 2 companies	1 (DE)	principal investigator
GRANteD	Grant allocation from a Gender Perspective (RFO managers, established researchers) http://www.granted-project.eu	2021-2023	5 RFOs, RPOs		external evaluator
HBP	interdisciplinary neuroscience project with Gender Action Plan (GAP) (scientists of all career stages, managers of science) www.humanbrainproject.eu	GAP: 2017-2022 (Runtime: 13-23)	154 RPOs, hospitals	16 (EU, UK, IL, CH)	partner (gender and change expert)
TU Graz	Communities of Practice for Accelerating Gender Equality and Institutional Change in Research and Innovation https://act-on-gender.eu	2015 ongoing	2 university, company	1 (AT)	internal research and gender units, external expert

2 Brief Description of the Contributing Projects

The H2020 project ACT aimed at overcoming struggles in implementing gender equality plans through the advancement of **communities of practice (CoPs)**. Thus, the focus was on enabling effective inter-organisational sharing of experiences from gender equality work to support structural change in RPOs and RFOs across Europe. Most of the individual CoP members were either researchers or worked in the **Human Ressources (HR)** department or as **Gender Equality (GE)** officers. The ACT project comprised seven CoPs, which were quite heterogeneous in their thematic focus (e.g., gender budgeting, GE in Life Sciences or Physics) and membership composition (132 CoP members came from universities, research organisations, funding organisations and research associations). The evaluation was carried out by JOANNEUM RESEARCH to assess the effectiveness of the CoPs and to identify the added value of membership via a quantitative survey among the CoP members and facilitators (n=77), monitoring and progress reports and semi-structured online interviews with all CoP facilitators (n=7) and a selection of CoP members (n=21).

Arqus European University Alliance aims to foster its cooperation in research, teaching, administration and social commitment. One of the so-called Arqus Action Lines, "Research Support and Early Stage Researcher Development" (chaired by a team in Graz), focuses on encouraging doctoral candidates and postdoctoral researchers to participate in joint initiatives such as a Mentoring Programme. Due to the Covid-19 pandemic the concept focused on online mentoring and regular peer groups for 21 mentees and CoPs for mentors (of different genders and disciplinary backgrounds) by ESR support units in all universities. Insights from the Arqus Mentoring Programme shared in this paper are based on feedback groups with mentors, mentees, results of a satisfaction survey with all participants, as well as review meetings between the organisers from the University of Graz and the mentoring facilitator.

With **CHANGE** six RPOs have supported change agents across Europe (Austria, Belgium, Germany, Israel, Portugal, Slovenia, Slovakia) to design, promote and implement gender equality plans (GEPs). Partners have exchanged gender equality knowledge and expertise with other RPOs as well as RFOs through mutual learning and networking. With such a co-production of knowledge approach and by building CoPs among RPOs and RFOs in each participating region, support and mentorship structures have been established. Members of these CoPs act as change agents in their organisations stimulating institutional cultural change towards gender equal work environments in RPOs and fostering the importance of gender dimension inclusive research and innovation programmes in RFOs. The experiences of change agents and their mutual support in CoPs were documented in workshops and focus groups.

The Human Brain Project (HBP) started in 2013 and is one of the largest research projects in Europe. Over 500 scientists and engineers from more than 140 universities, teaching hospitals, and research centres across Europe are currently participating mainly online. The HBP has improved the gender balance in leadership positions from 16% in September 2017 to 36% in January 2022 based on a Gender Action Plan, involving a **Diversity and Equal Opportunities Committee (DEOC**), the **Directorate (DIR)** and the **Science and Infrastructure Board (SIB)**, collaborating mainly online. The DEOC can thereby be considered as a network of 25 change agents of the HBP, co-creating and implementing measures with support of the 7 DIR and the 14 SIB members. To reflect the measures and their effectiveness as well as the impact of the Covid-19 pandemic, the authors carried out a survey on collaboration and diversity for all scientists, engineers, and service staff. Additionally, the participants of the mentoring programme (45 mentoring partnerships over a four years period) were asked to reflect their experiences via questionnaires and workshops.

GenderNetz investigated the influence of informal support structures and networks on research careers in engineering and information technology in Germany. In particular, the postdoc phase and its subject-specific career conditions on the way to a professorship were analysed in this national project. The findings from the GenderNetz project are based on 32 interviews with postdocs, 31 interviews with professors as gatekeepers (who are at the same time supervisors, funders, sponsors of the pre- and postdocs), as well as 12 focus group interviews with change agents, conducted before the Covid-19 pandemic. Additionally, two workshops with female early career researchers in academia and industry and three workshops with change agents from RPOs were conducted focusing on how to maintain professional social relationships in virtual academia, the role of professors as gatekeepers and recommendations.

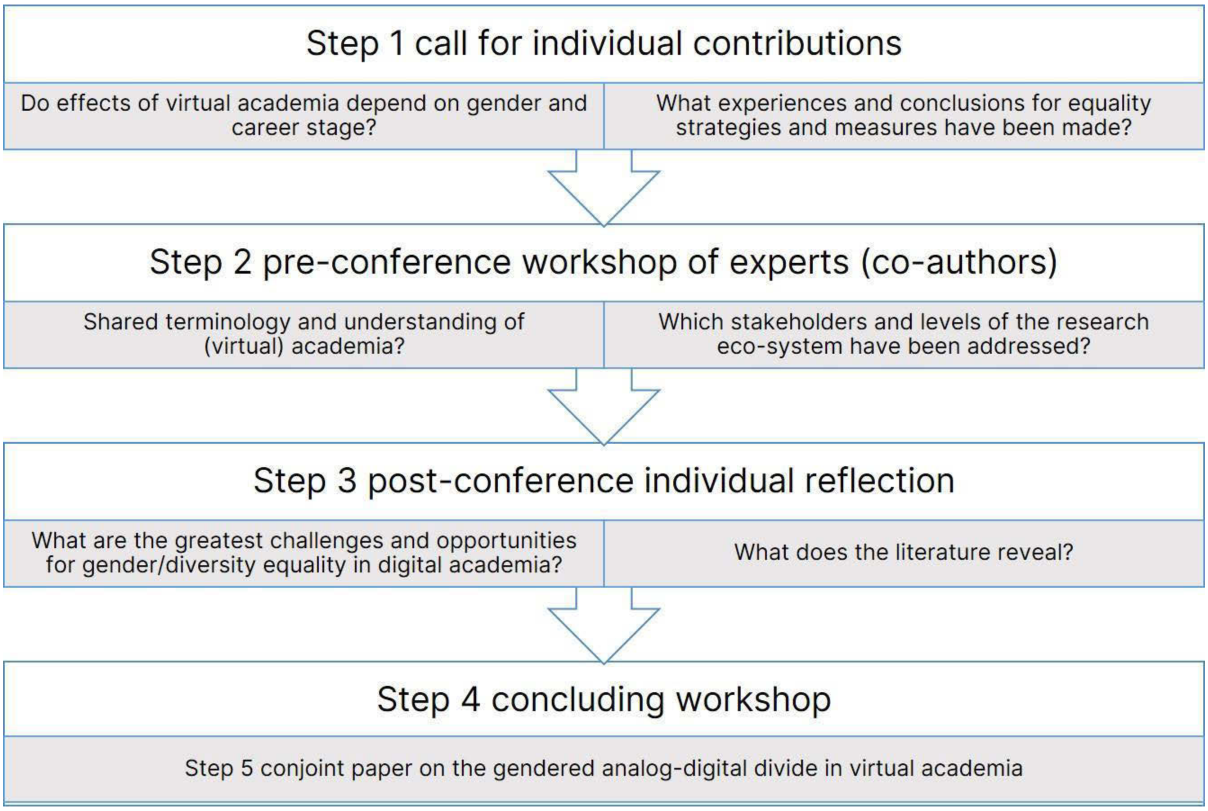
In **GRANteD** the allocation of research grants is studied from a gender perspective, aiming to identify potential factors of gender bias. Based on this research, recommendations are developed for RFOs but also for a more inclusive research system in general. Today, research grants are of increasing relevance for building an academic career. Thus, how grants are allocated and how scientific merit is assessed is relevant for an inclusive academic workforce. To identify (potential) gender bias in the grant allocation process, each of the five case studies, policies have been analysed and surveys have been sent to applicants from each RFO to learn more about their career ambitions, about their subjective belonging to the research system and their assessment of the granting process. Furthermore, interviews are conducted with staff members and RFO management (in total 5 to 10 per RFO) to learn more about how policies are applied in practice. In some RFOs, panel members are interviewed (approx. 25 per RFO). In others, panels are also observed in real time (in total five observations). Some preliminary findings by the co-author of these observations are discussed below, illustrating how the assessment and allocation of research grants was impacted by the virtual format of panel meetings.

TU Graz has developed a strategy called "Integrating Diversity in University's Key Areas" (IDuK) over the years since 2009 when the rectorate established a working group for Gender and Diversity to establish common ground (Grasenick, Kleinberger-Pierer, and Pilinger, 2020). The members of the working group have proven to be important change agents initiating and communicating measures for diversity and inclusion. Since 2015, research and teaching have been set as new strategic fields of action. Its participatory implementation and continuous development involve several service departments as well as scientists, lecturers, students, and trainers. Support structures and guidance have been established while during the Covid-19 pandemic all related measures were continuously offered virtually. More specifically, a training course on gender and diversity competencies for 12 scientists, a lecture series across all departments and virtual mentoring and coaching for 20 predocs have been carried out, reflected, analysed and results contributed to this paper by the responsible support units and researcher (co-author). Measures were open for all genders and career stages.

2.1 Methodological design of the validation process

The process to reflect and validate the effects of virtual academia as experienced by the various actors involved to enhance gender equality shares some similarities with the Delphi method (Giannarou and Zervas, 2014; Landeta, Barrutia, Lertxundi, 2011). It started with a call for contributions focusing on the impact of digitalisation and remote work on gender equality in science and technology at the **Science, Technology and Society Unit (STS)** conference (cf. Figure 2). Thus, co-authors first provided contributions based on their personal expertise and the related project reports. In a pre-conference meeting all abstracts were shared and structured. Thereby the different levels of the research ecosystem (Carayannis and Campbell, 2009) were addressed: universities and other research organisations, research funders and various support-structures, like CoPs, networks, and change agents as well as researchers of different genders and career stages. Workshop results were analysed and a second phase of individual reflection of co-authors followed. The resulting contributions were shared and the individual reports were discussed again in an online meeting.

Figure 2: Methodological design of the validation process. Source: own illustration



3 Digitalisation and Individual Academic Careers

Digitalisation has affected all areas of academia: teaching, research as well as interaction and collaboration. Especially for ESR who are not yet well known in their communities, interacting virtually impacts how working relationships with colleagues, mentors, supervisors and potential future collaborators are built. Those who are granted opportunities and resources to meet in person and/or have access to state-of-the-art tools, support and training programmes are privileged. Research on the impact of the Covid-19 pandemic has shown that working in the office (showing presence) gains further higher appreciation than working at home in home office (Ziegler et al., 2022). The office is a very important place for ESRs to show their commitment and devotion to scientific work. In a culture of informal hiring for qualifying positions, this increases their chances of being perceived by the supervisor as a promising candidate for a career in science. Thus, in times of home office demands working in the office is even more a privilege that mostly is granted to men.

Simultaneously, virtual academia offers new opportunities to connect pre- and postdocs, ESR with colleagues and experienced scientists across different universities, thus expanding their networks internationally and independently from their supervisors via formally planned measures such as online mentoring.

3.1 Networking as a key task for ESR

Networks are central to successful career trajectories, facilitating collaborations, publications, and citations (Husu, 2004). Network ties increase researchers' chances to receive a grant and to progress in their career (Wennerås and Wold, 1997).

From the perspective of ESR, networking in virtual academia is particularly challenging. Structural factors, above all, also influence the networking opportunities and strategies of predocs and postdocs (Ibarra, 1993; Burt, 1998). Especially postdoctoral researchers often lack support comparable to **Master (MA)** or **doctoral degree (PhD)** programmes. In the digitally conducted group discussion and surveys (GenderNetz workshops, HBP, Arqus, TU Graz) the questions of how they maintain their professional social relationships and how they go about becoming visible at online conferences, were of main concern and strategies were discussed accordingly. During the pandemic, ESR tried to gain visibility in their scientific community via social media like Twitter, LinkedIn or XING or by communicating at online conferences via video conference tools and follow up E-mails. While trying to make the best out of digital communication platforms, they are also aware that social events around non-digital conferences, project meetings, excursions etc. are the most important places for meaningful networking and building up valuable contacts (GenderNetz workshops) This is especially true for hybrid formats that bare the high risk of increasing the gap between those with sufficient financial resources and support and those who lack support and/or have family obligations hindering their presence at the venue and thus hindering the informal talks, whereby one misses out on crucial information and the opportunity to build trustful relationships. Particularly women, especially female ESRs, are affected by this development as male researchers were the first ones to return to

in-presence academia and as it is difficult to establish or enter networks virtually (Ziegler et al., 2022).
Thus, based on experiences shared by concerned ESR of the listed projects, it can be assumed that these strategies are not very effective with regards to network building: While virtual academia enables those who have less travel budget to tune into conferences or even present first achievements, the opportunities to build good personal relationships with peers and experienced professors are much more restricted (Henderson, 2021).
For women, as a strongly underrepresented group in the technical sciences, there is also a particular challenge for some to specifically approach male colleagues and “gatekeepers" in the scientific community. Lacking support for women in academia has been discussed in various studies and is often related to the preference for homophile ties (Bird, 1996; van den Brink and Benschop, 2014) network ties increase researchers’ chances to receive a grant and to progress in their career (Wennerås and Wold, 1997).
A key finding of the GenderNetz-project was that gatekeepers are often not aware of their personnel responsibility for ESRs and that they have different awareness and attitudes toward networking practices and their gender biased implications (Wolffram et al. 2020), which risk to be increased by virtual academia. This risk for falling behind due to lack of resources and/or family obligation is especially the case for ESRs who are highly aware of networking requirements in order to push their careers.

3.2 Online mentoring supporting ESR networking

To enable meetings with peers and experienced researchers on a regular basis formal virtual mentoring can be successfully established across different universities and countries. The online setting can take into account individual needs of the researcher, e.g. if they have care obligations that restrict travel, have a hearing or visual impairment or are restricted in their physical mobility. Especially the Covid-19 pandemic showed that flexibility and adjustment to virtual settings are crucial for today’s working environment in academia.
Online mentoring programmes as implemented by the HBP and Arqus have shown that constant communication, especially personal calls to check in with colleagues and peers (Grasenick and Guerrero, 2020), are important to prevent mentor-ing partnerships from getting lost in “cyberspace”. These personal connections counteract a lack of community feeling and trust, although needing more resources, a higher workload for the organisers, facilitators, and trainers of the programme.
While offering a low threshold, flexible support online mentoring can take an intersectional approach by considering several factors that concern a certain group more than others, e. g. career stage, caring obligations and ethnicity or race.
As stated above, female researchers are more affected by the negative aspects of these work conditions. This might be one of the reasons why female professors might

have greater awareness of challenges than early-stage researchers, and in particular female ESR. Female researchers thus tend to be more willing to fulfil the mentoring role to alleviate these challenges. Mentoring can thus be seen as academic care work, which is taken on largely by female researchers, reflecting the general distribution of care work within society. It is thus essential to appreciate supervision and mentoring as equivalent to publications in grant and tenure application so that this care work is being recognized.
Additionally, the need for systemic changes such as formal regulations that involve gate keepers as well as more open solutions tailored to the institution were addressed by participants of surveys, interviews and workshops (GenderNetz workshops, HBP). A central open approach is to establish and maintain contact with those professors who have already become visible as responsible and ESR-oriented supervisors to become more active change agents and acknowledge their contributions, for example, through awarding prizes. A more formal approach aims at obliging professors (or newly appointed professors) to participate in workshops of self-awareness and reflection about their own careers and what they would have done differently (GenderNetz workshops, HBP). Change agents additionally suggested concrete regulatory models or a clear career code for the support of ESRs within their institutions. Thus, every ESR should be obliged to go through an 'internship' period accompanied by a professor as mentor (CHANGE, GenderNetz workshops).

4 Networking among Change Agents and Communities of Practice

The Covid-19 pandemic not only impacted the careers of researchers, but also the workload and collaboration of change agents for gender equality in their organisation and international projects. Some of them were already prepared to work mainly online (international CoPs, committees and working groups of international projects) (ACT, Arqus, HBP, TU Graz). Like online mentoring, virtual exchange formats have offered opportunities for change agents to exchange experiences and support each other. Interviews and focus groups demonstrate that compared to ESR networking, building trust and supportive relationships becomes easier with work experiences – which is usually related to already having a personal network established. Such virtual formats can even be beneficial within institutions that might be locally distributed across different buildings, districts or countries. Benefits rise with the distance of contributors, when connecting on European or even international level.

4.1 Change agents in a virtual world

Building knowledge and expertise solely virtually can be successful: CoP members reported that they received inspiration for their GE work or felt motivated to initiate change processes in their organisation. Members appreciated the collaborative aspect of the CoP, especially the interdisciplinary cooperation, which opens new perspectives and strategies. A central benefit of CoPs for members was access to new people. When trust is established, they know where to turn to for a safe space, help, support and solidarity.

Yet, even though the networking proved to be beneficial, it is helpful if CoPs are partially planned virtually from the outset and are not surprised by a pandemic, as in the case of ACT. Not surprisingly, for the CoPs who had never had the chance to meet in person, the community building was harder than for the ones who did. Gendered effects of the pandemic too became evident, as supporters, change agents etc. have been mainly women, still to a much greater extent responsible for family obligations to which virtual meetings are not the solution (e.g., home schooling). Additionally, the individual workload increased due to the shift to online teaching and collaboration as well as additional support tasks. For many change agents, this was associated with emotional strain (ACT, HBP).

Facilitators have played a crucial support role in online communication under such demanding and stressful circumstances. Adapting duration and design of meetings, tact and sensitivity, reaching out to everyone without burdening members of a CoP, Working Group or Board with additional work has proved to be important. Thus, to increase resilience, we can learn that the well-being of a community and its members has priority over their activities (Thomson et al. 2021; Grasenick and Guerrero, 2020; ACT, HBP) and will finally lead to an open and frequent interaction.

The CoP facilitators also wished for more training and exchange and intervision between them to address questions of adequate technological solutions, group building, leadership, moderation, conflict management etc. (Reidl et al. 2022). So, when starting networking activities, one should think about the skills, competencies and resources that are needed and especially how the implementers can be supported during the process. As the development of a CoP is a fluid process, these needs change and an open flexible approach is thus crucial.

Even though virtual CoPs may be somewhat less costly for the members to participate, financial support for a CoP is crucial and should ideally be long-term. Community building takes time and online formats need to be well conceptualised, prepared and supported as well – an effort which should not be underestimated. Thus, the central limitations of the CoP approach – and probably many other networking approaches – are financial and time resources. CoPs need resources for at least a basic facilitation and members need resources to engage (Reidl et al. 2022, Arqus, HBP, TU Graz). However, compared to face-to-face work, online collaboration can be somewhat lower threshold (i.e. saving time and travel costs) for change agents who do not have sufficient resources.

In the CoP member organisations, some noted a change in the relevance of the issue of gender equality as the Covid-19 pandemic was seen as a priority and other issues were seen as less important. For example, some found it more difficult to engage internal stakeholders in their GE work (Sekula et al. 2022). It seems that the impact on

the internal GE work was less of a concern in organisations with highly developed GE structures.
Digital communication and collaboration are an opportunity for remote partnerships, co-creation and co-decision processes as well as for maintaining cross-institutional networks for change agents – if not considered as full substitute for face-to-face meetings and if accompanying measures are taken to monitor and counteract diverse impacts of digital work. Thus, when deciding whether to work online or face-to-face or how to best combine the different approaches, advantages and disadvantages must be carefully weighed up.
These experiences can easily be transferred to RFOs that now also need to have a GEP when applying for **European Commission (EC)** funding. In CoPs, RFOs too can share mutual experiences of what has worked in practice and what failed – this refers to the whole funding cycle.
With Horizon Europe's GEP eligibility criterion it can be assumed that this exchange and support on GE between research (funding) organisations in Europe will become even more necessary. Especially newcomers might appreciate the inspiration and support from other GE change agents and practitioners, which can be realised by the participation in online communities of practice.

5 Decision Makers in Virtual Academia

While the effects of the Covid-19 pandemic are obvious on the level of less experienced researchers it is yet unclear how RFOs take the pandemic into account and become active in their role of assessing scientific merit.
Change agents participating in CoPs, a change in the relevance of the issue of gender equality could be observed as managing the pandemic gained high priority while other issues were seen as less important. For example, some change agents found it more difficult to engage internal stakeholders in their GE work. It seems that the impact on the internal GE work was less of a concern in organisations with highly developed GE structures. However, it was also reported that some stakeholders became more aware of gender issues when these were highlighted in the public debate of the Covid-19 pandemic. For example, a university with comprehensive gender structures gender-mainstreamed all Covid-related measures for students, while others feared that the topic of gender equality might disappear completely from their organisation. Crises such as the Covid-19 pandemic therefore carry the risk of widening the gap between advanced organisations and newcomers to GE work (ACT).

5.1 The role of RFOs

RFOs play a crucial role when it comes to deciding how the research system and research careers are constructed and how scientific merit is assessed (Witteman, Haverfield, and Tannenbaum, 2021). Already before the Covid-19 pandemic, RFOs

have worked hard to design and implement new policies to increase the transparency of the assessment process and also its gender fairness and inclusiveness (like assessing the gender-in-research dimension). Peer review panels as bodies to assess the quality of proposals are at the core of the grant allocation process – they are of specific relevance for gender-fairness, and this holds also or even more in times of the Covid-19 pandemic. RFOs define rules and policies to optimise the quality of the assessment in panels, also aiming for more gender fairness, in online as well as in onsite settings (GRANteD).
Here it must be considered that framework conditions differ in countries and partially on institutional level. For example, some decision-making bodies only met virtually, others still or partly face-to-face; some RFOs extended the runtime of projects (GRANteD). Additionally, to differences in strategic measures for gender equality such as childcare, parental leave or career support measures, also Covid-19 related restrictions varied between countries (HBP). In large and complex projects such as the HBP, the project itself is requested to act as RFO by defining **calls for expressions of interests (CoIs)** and assessing the proposals. While little is known about panels suggesting proposals in general, the HBP has provided reports on the assessment procedures which have been carried out solely virtually. By supporting applicants as well as juries with detailed guidelines and examples on how to consider gender and diversity for team members as well as in research content, the participation of women and the quality of the proposals were improved significantly (HBP).

5.2 Virtual reviews and panels

Other RFOs have modified their assessment process, enabling a review of the remote review process (GRANteD). This way, a quality assurance of the remote reviews was implemented. Learnings from this process might be of specific relevance when more reviewing is done virtually in the future. In the remote review, gender is taken into account when remote reviewers are to assess if/how the gender dimension in research content is addressed. From a gender perspective this illustrates that the gender awareness of remote reviewers becomes more relevant; in particular as they do not have the chance to discuss their assessment but do it by themselves. Thus, when more assessment is done virtually, funding organisations should make sure that remote reviewers are gender aware.
In general, the composition of virtual panels is expected to be more inclusive and gender-fair, simply because people with care obligations would need less time and could avoid travelling; this would favour women who still do most of the – due to Covid-19 increased – care work. Yet RFOs reported that in the pandemic, female researchers more often reject the invitation to become a panel member than male researchers (GRANteD). This was on the one hand explained by the additional workload due to care obligations and virtual teaching. Also, it was argued that people get used to virtual

meetings, thus they schedule more meetings than they would do onsite with less breaks in between. This increases the workload and people feel more stressed and less able to participate in virtual panels.
When observing panels, it becomes evident again how important adequate resources and expertise are. The chair acts as facilitator and is requested to have specific expertise on (gender) biases in academia. Here also RFO staff members play an important role as they explain formal details and provide advice in case the panel members are not sure how to implement new regulations in practice (GRANteD, HBP).

6 Conclusions: Counteracting the Analog-Digital Divide

The Covid-19 pandemic accelerated technologies, tools and their usage to collaborate professionally online, especially in academia. Opportunities to harvest the benefits vary strongly. Investigating the experiences that have been made by different actors of the academic system demonstrates that trustful, beneficial relationships can be built at all career levels and for different purposes if set up and supported professionally and need oriented. Virtual academia offers more opportunities to stay connected across distances and collaborate effectively with less need to travel. Thus, at an early career stage, researchers benefit by establishing networks across different universities, while change agents exchange experiences and expertise in CoPs. Especially for newcomer change agents, a virtual exchange can be a lower threshold (due to lack of time and financial resources) (Sekula et al., 2022).
In contrast, it has been demonstrated that for more experienced researchers the networks themselves are less important as they have already been established, instead, less travel time for meetings as members of juries, boards, projects are of relevance. However, the prevailing differences in academic and family care work are a high risk for individual career development.
Thus, the benefits of virtual academia also bare the risk of increasing gender and diversity imbalance – a phenomenon we define as analog-digital divide that refers to the difference created due to virtual academia by an unequally gendered distribution of analog and virtual resources:

1. Different opportunities to build trustful relationships by analog, in-person meetings
2. Different access to state-of-the-art tools and professional facilitation for virtual collaboration
3. Different distribution of academic care and family care work, whereas virtual academia is more demanding than analog support

To avoid new inequalities, such risks of the analog-digital divide need to be counteracted by RPOS and RFOs that set guiding frameworks and funding opportunities. Risk mitigation includes paying special attention to a fair balance of

academic care work, of opportunities to meet, to develop and maintain stable, supportive relationships and sufficient resources for professional tools and services. Furthermore, our analysis has emphasised the importance of detailed guidance for online assessment (remote reviews and juries).
When developing strategies and measures to enhance equal opportunities we conclude that it is important to include a thorough reflection of such potential inequalities and to counteract them, among others, by including indicators referring to the three risks of analog-digital divide when monitoring and evaluating equality measures, for instance by providing data on:

- The distribution of resources and opportunities to meet in person and to work at the office as well as measures dedicated for international virtual collaboration
- The access to resources for professional tools, process design and facilitation of virtual academia; monitoring of hybrid conferences and their inclusiveness for virtual attendees
- The amount of resources dedicated to guarantee a fair distribution of academic and family care work
- Personal, socio-economic background and career stage of actors to enable an analysis of the intersection of several aspects of diversity that contribute to the analog-digital divide

RPOs must pay special attention to the analog-digital divide when designing strategies and measures. A specific focus should lie on instruments and procedures enabling networks between ESR and established researchers across different academic institutions to support inclusive career development. Supportive resources to implement measures mitigating the effect of Covid-19 have been provided, e.g. by the European Institute for Gender Equality (EIGE) in the GEAR tool[4].
RFOs and funding juries must provide guidance accordingly with detailed questions and examples of good practices that are indeed considered in the evaluation process while acknowledging the various national and regional framework conditions of RPOs. The obligatory GEPs, the further emerging guiding materials and consultancies supporting their implementation are an opportunity to integrate the analog-digital perspective in strategies, specific measures and indicators for monitoring.

[4] https://eige.europa.eu/gender-mainstreaming/toolkits/gear/measures-mitigating-effect-covid-19

References

Amano-Patiño, Noriko; Faraglia, Elisa; Giannitsarou, Chryssi; Hasna, Zeina (2020): Who is doing new research in the time of COVID-19? Not the female economists. In Galiani, Sebastian; Panizza, Ugo (Eds.) *Publishing and Measuring Success in Economics*. London: Centre for Economic Policy Research, pp. 137-142.

Bagilhole, Barbara; Goode, Jackie (2001): The Contradiction of the Myth of Individual Merit, and the Reality of a Patriarchal Support System in Academic Careers. A Feminist Investigation. In European Journal of Women's Studies 8 (2), pp. 161-180. DOI: 10.1177/135050680100800203.

Bird, Sharon R. (1996): Welcome to the Men's Club: Homosociality and the Maintenance of Hegemonic Masculinity. In Gender & Society 10 (2), pp. 120-132. DOI: 10.1177%2F089124396010002002.

Burt, Ronald S. (1998): The gender of social capital. In Rationality and Society 10 (1), pp. 5-46. DOI: 10.1177/104346398010001001.

Carayannis, Elias G.; Campbell, David F.J. (2009): 'Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem, Business, Computer Science. In Int. J. Technol. Manag., DOI: 10.1504/IJTM.2009.023374.

European Commission, Directorate-General for Research and Innovation (2019): She figures 2018. Publications Office. DOI: 10.2777/936.

European Commission, Directorate-General for Research and Innovation (2021): She figures 2021: Gender in Research and Innovation: Statistics and Indicators. Publications Office. DOI: 10.2777/06090.

Fulweiler, Robinson W.; Davies, Sarah W.; Biddle, Jennifer F.; Burgin, Amy J.; Cooperdock, Emily H.; Hanley, Torrance C. et al. (2021): Rebuild the Academy: Supporting academic mothers during COVID-19 and beyond. In PLoS Biol 19 (3): e3001100. DOI: 10.1371/journal.pbio.3001100.

Gabster, Brooke Peterson; van Daalen, Kim; Dhatt, Roopa; Barry, Michelle (2020): Challenges for female academics during the COVID-19 pandemic. In The Lancet 395 (10242), pp. 1968-1970. DOI: 10.1016/S0140-6736(20)31412-4.

Giannarou, Lefkothea; Zervas, Efthimios (2014): Using Delphi technique to build consensus in practice. In International Journal of Business Science & Applied Management, 9(2), pp. 65-82.

Grasenick, Karin; Kleinberger-Pierer, Magdalena; Pilinger, Armanda (2020): Taking Diversity in Research Projects into Account: How to make it work? Verlag der Technischen Universität Graz. DOI: 10.3217/978-3-85125-753-3.

Grasenick, Karin; Guerrero, Manuel (2020): Responsible Research and Innovation & Digital Inclusiveness during Covid-19 Crisis in the Human Brain Project (HBP). In Journal of Responsible Technology 1, Oct. 2020. DOI: 10.1016/j.jrt.2020.06.001.

Henderson, Emily F. (2021): Sticky care and conference travel: unpacking care as an explanatory factor for gendered academic immobility. In High Educ 82, pp. 715-730. DOI: 10.1007/s10734-020-00550-1.

Husu, Liisa (2004): Gate-keeping, Gender Equality and Scientific Excellence. In Brouns, Margo; Addis, Elisabetta (Eds.) *Gender and Excellence in the Making*. Brussels, European Commission, pp. 69-76.

Ibarra, Herminia (1993): Personal Networks of Women and Minorities in Management: A Conceptual Framework. In The Academy of Management Review 18 (1), pp. 56-87. DOI: 10.2307/258823.

Kleinberger-Pierer, Magdalena; Pohn-Weidinger, Simon; Grasenick, Karin (2020): Fair Projects – Bad data? Evaluating the Gender Balance in Science Projects. In fteval Journal for Research and Technology Policy Evaluation 50, pp. 60-71. DOI: 10.22163/fteval.2020.471.

Landeta, Jon; Barrutia; Jon, Lertxundi, Aitziber (2011): Hybrid Delphi: A methodology to facilitate contribution from experts in professional contexts. In Technological Forecasting and Social Change, 78(9), pp. 1629-1641. DOI: 10.1016/j.techfore.2011.03.009.

Meyerson, Debra; Tompkins, Megan (2007): Tempered Radicals as Institutional Change Agents: The Case of Advancing Gender Equity at the University of Michigan. In Harvard Women's Law Journal 30 (2), pp. 303-320.

Oleschuk, Merin (2020): Gender equity considerations for tenure and promotion during COVID-19. In Canadian Review of Sociology 57(3), pp. 502-515. DOI: 10.1111/cars.12295.

Parsons, Elizabeth; Priola, Vincenza (2013): Agents for Change and Changed Agents: Micro-politics of Change and Feminism in the Acadamy. In Gender, Work & Organizations 20(5), pp. 580-598.

Reidl, Sybille; Beranek, Sarah; Holzinger, Florian (2022): Benefits and limits of a CoP approach to promote gender equality in R&I. In Palmén, Rachel; Müller, Jörg (Eds.): *A Community of Practice Approach to Improving Gender Equality in Research*. Routledge Research in Gender and Society. London and New York, pp. 168-186.

Sekula, Paulina; Ciaputa, Ewelina; Warat, Marta; Krzaklewska, Ewa; Beranek, Sarah; Reidl; Sybille (2022): Communities of Practice and gender equality – Fostering structural change in research and academia in Central and Eastern Europe. In

Palmén, Rachel; Müller, Jörg (Eds.): *A Community of Practice Approach to Improving Gender Equality in Research*. Routledge Research in Gender and Society. London and New York, pp. 82-100.

Thomson, Aleksandra; Palmén, Rachel; Reidl, Sybille; Barnard, Sarah; Beranek, Sarah; Dainty, Andrew R. J.; Hassan, Tarek M. (2022): Fostering collaborative approaches to gender equality interventions in higher education and research: the case of transnational and multi-institutional communities of practice. In Journal of Gender Studies, 31:1, pp. 36-54, DOI: 10.1080/09589236.2021.1935804.

Witteman, Holly O.; Haverfield, Jenna; Tannenbaum, Cara (2021): COVID-19 gender policy changes support female scientists and improve research quality. In Proceedings of the National Academy of Sciences Feb 2021 118 (6) e2023476118. DOI: 10.1073/pnas.2023476118.

van den Brink, Marieke; Benschop, Yvonne (2011): Gender practices in the construction of academic excellence: Sheep with five legs. In Organization 19 (4), pp. 507-524. DOI: 10.1177/1350508411414293.

van den Brink, Marieke; Benschop, Yvonne (2014): Gender in Academic Networking: The Role of Gatekeepers in Professional Recruitment, In Journal of Management Studies 51 (3), pp. 460-492. DOI: 10.1111/joms.12060.

Viglione, Giuliana (2020): Are women publishing less during the pandemic? Here's what the data say. In Nature 581, pp. 365-366. DOI: 10.1038/d41586-020-01294-9.

Wenger, Etienne; McDermott, Richard Arnold; Snyder, William (2002): Cultivating Communities of Practice: A Guide to Managing Knowledge. Harvard Business Press.

Wennerås, Christine; Wold, Agnes (1997): Nepotism and sexism in peer-review. In Nature 387 (6631), pp. 341-343. DOI: 10.1038/387341a0.

Wolffram, Andrea; Dahmen-Adkins, Jennifer; Dorgeist, Matthias; Göttgens, Anne; Rieger, Ronja; Schulz, Astrid (2020): Netzwerke und Networking in der Postdoc-Phase technischer Disziplinen – Eine Handreichung für die Praxis. Aachen: STO, RWTH Aachen University. Available at https://gendernetz.de/wp-content/uploads/GenderNetz_Broschuere.pdf [24.08.2022]

Ziegler, Yvonne; Graml, Regine; Vincenzo, Uli (2022): Stereotyping and Gender Gap During COVID-19: Backlash or Gender Convergence? A Systematic Literature Review. In Proceedings of the 5th International Conference on Gender Research, Aveiro, Portugal, pp. 274-280. DOI: 10.34190/icgr.5.1.94.

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(Dis)Assembling Predictive Stability: On the History and Culture of Survey Sampling for Election Forecasts

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Abstract. This essay explores the history of election forecasting alongside the history of survey sampling. In doing so, the following contributes to contemporary scholarship on cultures of prediction, suggesting the notion of predictive stability as a way to conceptualise predictions in social science. In taking an ANT-informed perspective, this essay shows how the development of a stable culture of prediction hinges on the assembling of heterogeneous actors, which stabilisation often takes place in the aftermath of major elections. In order to arrive at this conclusion, the essay will proceed as follows: I will first introduce the topic of cultures of predictions in the social sciences and opinion polling, through which I develop the concept of predictive (in-)stability. After this, I will briefly draw on the history of election forecasting and the history of survey sampling to show that new sampling methods are usually not adopted when their superiority becomes apparent, but when predictive instability of the old ones comes to the fore. In doing so, I will show how the evaluation of pre-election polls informs the way polling is done in general, which in turn, leads to closure regarding the general accepted methodological approaches. This closure is oftentimes reached in the aftermath of major elections.

1 Introduction

How do we know what voters know?[5] Should pre-election polls be 'trusted' as tools of prediction, or feared as mechanisms of distortion, making voters falsely certain of a probable win or loss? Controversies around the metaphysical possibility, as well as the societal role of pre-election polls, have sparked since their first appearance in the early 19th century and have not stopped the progress technologies of election forecasting have made. Especially since the 1950s, social scientists have developed a sophisticated and distinctive methodological apparatus with which to access the social world and to tap into public opinion: The sample survey, therefore, allows to extrapolate statements for a whole population based on limited pieces of it. Particularly in the aftermath of major drawbacks in the 1930s and 1940s, election forecasts based on

[5] I would like to thank the two anonymous reviewers, the organizers, and participants of the conference, in particular of the panel on Cultures of Prediction, as well as Manuel Jung and Pablo Cabrera Alvarez for their helpful thoughts and comments.

opinion polls developed to become a lucrative business. Furthermore, the triumphal procession of election forecasting led to a perception of trust in pollsters, which, however, eroded from time to time. Especially over the past decade, we have seen traditional polls fail in predicting the results of major elections around the world, leading to widespread mistrust in polling data.
The history of election forecasting is intrinsically linked with the history of statistical sampling. When considering both, it is interesting to see how despite consensus regarding the superiority of certain sampling methods, opinion pollsters and election forecasters are generally very slow to adopt those approaches. In particular, we can see that the polling industry mainly adapted new techniques when previous ones fell short in predicting an election, not when their inferiority has been shown theoretically. In order to understand this phenomenon, I will draw on actor-network theory to develop the notion of *predictive (in)stability* to conceptualize how cultures of prediction assemble and resolve. In order to do so, I will first explore the notion of cultures of prediction in relation to social scientific predictions to lay the ground for a subsequent analysis of how such a culture of prediction in the case of election forecasting emerged. I will then discuss the question as to how stable networks emerged and eventually dissolved, for which I draw on the distinction I suggest between opinion polls with predictive content from those without. In a last step, I will develop an understanding of epistemic closure that hinges on the strength of those very networks and their ability to assemble and maintain predictive stability.

2 The Predictive Apparatus

2.1 Some Notes on Actor-Network Theory

The subsequent analysis of the development of the polling apparatus is guided by the methodological tenets of Actor-Network Theory (ANT). Despite being labelled a theory, ANT should rather be understood as a methodological approach to doing social research in heterogeneous settings involving human and non-human entities. Thus, one of the key aspects of it is the overcoming of classical dualisms, such as subject/object, or nature/culture. Instead, heterogeneous actors are assembled in actor-networks, through which practices and associations can gain stability. Such an orientation implies a renunciation of the dichotomy of a knowing subject and an object one wants to further know, instead emphasising the process of mutual knowledge creation. One way to explore how the world becomes represented through statistics and polling points toward the interplay of practices, actors and technologies, a relation that can nicely be illustrated by the concept of 'statistical chains', understood as "institutionalized social processes which allow to generate data" (Diaz-Bone and Horvath, 2021: 220).

ANT is therefore interested in how networks transform themselves through the enrolment of new actors or the dissolvement of old ones. One central term is the actant, which Latour uses to account for the role of nature in the make-up of theories in science. ANT refers to the notion as a means to methodologically treat humans and non-humans symmetrical, it is "something that acts or to which activity is granted by others. It implies no special motivation of human individual actors, nor of humans in general. An actant can literally be anything provided it is granted to be the source of an action" (Latour, 1996: 373). The identity of actants is shaped in and through these transformations and the relationships between different actors in the network. Their differences do not hold *a priori* but are effects of actor-networks. Only when such networks become concrete and gain stability, they become actors.

As we shall see later in the essay, the making of knowledge in opinion polling hinges on a variety of actors, which stability is crucial to serve as an apparatus of prediction. When looking at the history of sampling, it will become apparent how different actants, such as newspapers, statisticians, respondents, sampling techniques, landline phones or the public had to enter into particular orderings and relations in order to gain stability. For instance, due to the dissolution of landline phones, traditional sampling techniques partly lost their power as respondents stopped participating, through which the predictive apparatus lost stability. Thus, a new actor, the non-respondent emerged as a threat to the stability of previous ways of polling. This new situation afforded many rearrangements within the predictive apparatus. Following ANTs line of thought that the establishment of scientific facts "comes down […] to placing these actors in a stable network" (Detel, 2001: 14265), I will argue that *predictive stability* is the key dimension for the successful establishment of a culture of prediction in (social) science.

2.2 Prediction in the Social Sciences

All aspects of human life are guided by a sense that we are aware of our limited knowledge of what is yet to come. As social beings, we are oriented toward the future and have a practical interest in gathering knowledge about what will happen. This is often associated with attempts to gather foreknowledge, one of which is to make predictions. Predictions are statements about a future state of the world, for example about the weather or the outcome of an election, to use examples from different domains. Predictions in the natural sciences, however, differ from predictions in the social sciences in important ways, which have to do with the nature of the social and the natural world.
There is a major obstacle to predictions in the social sciences, which anti-naturalist philosophers of (social) sciences have long pointed out: Whereas I can go out to check whether the weather forecast's prediction of a sunny afternoon actually turned out to be correct, predictions in the social sciences contain additional layers of uncertainty,

as the predictive claim can elicit or suppress certain behaviour. As Guala (2015) summarizes, this distinctive feature of human nature has been given various names, such as "self-fulfilling / defeating prophecy" (Merton, 1948), "interactivity" (Hacking, 1999), "reflexivity" (Soros, 2013), or "performativity" (MacKenzie, 2006) and points toward the theory-dependency of social behavior. While the weather doesn't care about what the weather forecasts say about it, the electorate often cares a great deal about what the current election forecasts say about their future voting behavior. Hacking formulated this as follows: "A cardinal difference between the traditional natural and social sciences is that the classifications employed in the natural sciences are indifferent kinds, while those employed in the social sciences are mostly interactive kinds. The targets of the natural sciences are stationary. Because of looping effects, the targets of the social sciences are on the move" (Hacking, 1999: 108). Due to this lack of stability, social kinds don't support predictions and explanations in the same way as is the case for natural kinds. If a predicted scenario is undesirable, it can mobilize individuals or groups to engage in behavior to avoid or alleviate its impact, to change one's voting intention or not vote at all. Similarly, a predicted scenario that is desirable might equally lead to a particular behavior to further support a certain outcome.

As a matter of predicting human behavior, election forecasts are a suitable example of these kinds of claims. Elections are open systems and display a variety of variables that cannot all be modelled. As Northcott (2015) infers from these kinds of considerations regarding the metaphysical possibility of predicting elections, they do not fulfil the metaphysical conditions supposedly necessary for predictive success (see: Northcott, 2015: 1262). Northcott, however, makes the case that methodological considerations rather than metaphysical ones are at the bottom of successful election forecasting. He argues that the crucial element of the successful prediction lies in the "sophisticate use of case-specific evidence from opinion polling" and not the "pursuit of explanations via general theory or causal mechanisms" (Northcott, 2015: 1260). What is pivotal to successful election forecasts is a certain methodological approach. In the following, I want to follow this line of thought and argue that the success of election forecasts does not lie in the metaphysics of elections, but that it hinges on the development of a stable culture of prediction, involving methodologies, respondents, the media, and others. Therefore, it will be necessary to move one step back to trace the development of a more basic methodological apparatus, namely the sample survey. I will argue that it is precisely due to the difficulties and metaphysical impossibility of predicting election results that a strong and stable culture of prediction is of crucial importance for there to be prediction in the first place.

2.3 Cultures of Prediction

In their seminal work, Heymann et al. (2017) refer to the work of Knorr-Cetina (1999) and state that “like any scientific culture, [cultures of prediction] operate in specific scientific and social contexts and reveal sets of shared knowledge, practices, values, and rules which emerge, stabilize, and shape scientific and public perceptions, conduct, and goals” (Heymann et al., 2017: 6). Following Knorr-Cetina, epistemic cultures are “amalgams of arrangements and mechanisms - bonded through affinity, necessity, and historical coincidence - which, in a given field, make up how we know what we know” (Knorr-Cetina, 1999: 1). Her interest is thereby “not in the construction of knowledge but in the construction of the machineries of knowledge construction” (Knorr-Cetina, 1999: 3). In other words, the question is how the practices and cultures of generating scientific knowledge emerged. When dealing with cultures of prediction, the focus should thus be on the particular arrangements, mechanisms, and practices of coming to know the future.

Drawing on the work of Fine (2007), Heymann et al. (2017) characterized cultures of prediction along five dimensions: (1) the social role of prediction; (2) the character and significance of computational practices; (3) the domestication of uncertainty; (4) the degree of institutionalization and professionalization of predictive expertise; and (5) the cultural impact of predictive practices and claims. Exploring the “constructions of the machineries of knowledge construction” (Knorr-Cetina, 1999: 3) leads our attention to the historical emergence of the instruments and the social practices through which the future is to be brought into the present. Because of its inherent uncertainty, predictions are usually embedded in cultures that serve to stabilize the predictive claims and establish their legitimacy. This allows for the possibility to have shared knowledge about what cannot be known with certainty.

To Fine, the practice of forecasting is “shaped by the contours of group life” (Fine, 2007: 2), rendering it “something akin to art, a personalistic and elusive process of interpretation” (Fine, 2007: 13). Furthermore, “[t]he dark heart of prediction is defining, controlling, and presenting uncertainty as confident knowledge” (Fine, 2007: 103). The question as to what constitutes sufficiently confident knowledge differs across different domains and cannot ultimately be answered: It is “not simply a matter of inventing practices to produce robust and reliable knowledge. It is a matter of conflict, negotiation, and boundary work and is intricately linked to the establishment of social credibility, legitimacy, and authority of scientific claims and policy responses” (Heymann et al., 2017: 27). The legitimacy and credibility of future claims thus have a conflictual nature and are negotiated within scientific communities and the public. Importantly, those cultures of predictions also “represent cultures of power and, hence, transformative forces, which are all the more effective as they are often black-boxed, hidden, and invisible” (Heymann et al., 2017: 7). Taking the perspective of ANT, the negotiation of credibility is successful if cultures of prediction assemble a stable actor-network. It is about establishing stable actor-networks in which the variety of interests and assumptions harmonize.

Cultures of prediction in the social sciences hinge on what I suggest calling *predictive stability*, referring to the socially shared expectation that predictive claims point toward the right direction. Stability lies in the establishment of networks between sampling instruments, stakeholders, respondents, the public, polling companies and others. Conversely, *predictive instability* refers to the societal shared expectation that predictive claims do not necessarily point toward the right direction. This can be differentiated from the mere capacity to make predictions, which shall be called *predictive capacity*. Predictive capacity alone does not allow any conclusion about the socially shared expectation of getting valid predictions.

2.4 Polling: Two Views

Before expanding on the development of a culture of prediction in election forecasting, I will briefly introduce a differentiation when it comes to opinion polling. Statistics as a discipline is always concerned with estimation, as it aims to estimate features of a population given features of a subsample of it. Election forecasting, however, comes with an additional layer, as it appears to predict an actual event to occur. While this differentiation may not be of relevance to most survey practitioners, as polls and surveys are seen as a method to estimate a characteristic of the population, the public expectation of election polls seems to support such a distinction. Thus, regarding the social attributes toward polling, I will suggest a differentiation between opinion polls without predictive content and opinion polls with predictive content:

- Opinion polls without predictive content: This form of opinion polling is concerned with the creation of knowledge regarding current states of affairs. One might, for instance, try to find out which politician is most liked among the populace.
- Opinion polls with predictive content: This form of opinion polling is concerned with the creation of knowledge regarding future states of affairs. One might, for instance, try to find out whether the majority of a given country will vote for candidate A, rather than for candidate B.

Looking at how, e.g., popular media reports about polling disasters, they are usually concerned with the second class of opinion polls, those with predictive content. The reason for this is that there will be a situation in which the estimation will or will not actually occur. A good track record of a polling company or the polling industry as a whole can thus be understood through the lenses of the concept of *predictive stability,* as predictions would be accompanied by a socially shared expectation that their claims point toward the right direction. In order to make more sense of this, let us consider the development of a culture of prediction in election forecasting.

3 The Emergence of a Culture of Prediction in Election Forecasting

3.1 The Scientificisation of the Oracle

3.1.1 Early Attempts of Election Forecasting

In his study on the origins of election polls, Smith (1990) points our attention to the 1824 US presidential election. This election is generally regarded as a realignment in American politics: While since the 1790s, the US party system was shared by the Federalists and the Democratic-Republicans, the Federalists ceased to be a relevant political power, leaving only the Democratic-Republican Party at the 1824 election. Without having a Federalist opposition, the party split and four of its candidates vied for the presidency. Uncertainty regarding the outcome of this election was particularly high, not only because of the several candidates, but also because they all ran as Democratic-Republicans. This had the effect that past voting behavior could not serve as a guide[6] (cf. Smith, 1990: 23). Not surprising, this confusing situation led politicians, newspapers, and others to attempt to predict the outcome of the election. Smith tells us that, for instance, the number of toasts made to the candidates during the Fourth of July celebration in Pennsylvania was seen as an indication of support toward the respective candidates. Despite drawing on such proxies, people began to conduct, what was later characterized as straw polls during public meetings, such as militia musters or tax gatherings. Those straw polls fulfilled the desire to both know about public opinion and to express one's own opinion. As it seems obvious to a contemporary reader, those straw polls were often highly biased and critiques of their representativity were already raised back then. Those early polls may have fulfilled a societal desire to gain knowledge about the future; the predictive apparatus, was, however, far away from reaching predictive stability.

3.1.2 Learning From Defeat: Assembling Predictive Stability

In subsequent years, a particular procedure evolved out of the variety of approaches that were conducted. Newspapers started to print questionnaires, which readers could fill out and send back. Their address registers were further extended in drawing e.g., on lists of car or phone owners. The Literary Digest plays a particular role here: In 1895, its file already contained more than 350 thousand addresses; by 1932, it had grown to 32 million. To predict the 1928 election result, for instance, the Literary Digest sent out 18 million questionnaires and was able to predict Hoover's victory surprisingly well (cf. Keller, 2001: 33p). Due to their successful track record, the Literary Digest's forecasts were viewed with great confidence and trust. Since the beginning of their polls in 1916, predicting the outcome of presidential elections based on opinion polls was successful five times in total, although the methods were not particularly

[6] Smith (1990) mentions other factors, such as the fact that multiple candidates were running without a party label, and more fundamental change in the political system. The right to vote was extended to all white males and the direct election of electors was introduced.

sophisticated at first. Due to the success of their election forecasts, there was no reason to question their sampling approach, the Digest's numbers were endowed with *predictive stability*. In 1936, however, the highly praised and trusted magazine failed miserably when it wrongly predicted Landon's victory over Roosevelt. We now know that the sample drawn by the Literary Digest was skewed towards wealthy people and not representative of the population.[7] At the same time, George Gallup (1901 - 1984), who was setting up his own polling company, drew a sample of 3,000 people using his own methods and predicted the Digest predictions long before they were published, with an error of only one percentage point. With another purposively drawn sample of about 50,000 people, he correctly predicted Roosevelt's victory, although his prediction of Roosevelt's vote share was also off by quite a bit. The popular and esteemed Literary Digest never recovered from this enormous loss of confidence, which is considered the main cause of the magazine's demise two years later. This episode highlights that methods must be examined not only based on their past track record. As Katz and Cantril (1937) stated back then, "[t]he selective error in the sampling technique of the Literary Digest was logically apparent long before it became empirically important. Merely because a method works fairly well on one or more occasions is no guarantee of its reliability" (Katz and Cantril, 1937: 176).

Twelve years after his brilliant election prediction, however, for the 1948 presidential election, a major polling disaster happened to Gallup himself. Gallup wrongly predicted a victory for Dewey over Truman. Gallup's election prediction enjoyed so much confidence at the time that the Chicago Tribune erroneously headlined "Dewey Defeats Truman" the day after the election. The reason for the misprediction was that the interviewers were allowed to choose whom to interview, given certain quotas. In each of the fixed categories (including gender, age, and economic status), republicans were apparently easier to reach. One of the results of these investigations was a critique of quota sampling (cf. Likert, 1948) and Gallup also drew this lesson from it and subsequently began to use random sampling as the basis for its surveys. Remembering Katz and Cantril's point, reconsidering the sampling technique deemed necessary after errors became empirically, not logically important. There was already definite evidence about the superiority of random sampling, it was already used in official statistics and yet, it was applied in the practice of polling only after *predictive instability* regarding quota sampling became apparent. This event finally led to epistemic closure regarding the best way of how to tap into public opinion. This consensus on the superiority of probabilistic sampling methods became the characteristic element of survey research and the polling industry. Today, opinion polls based on sample surveys are so ubiquitous that it is hard to imagine a world without

[7] The reason for the Digest's incorrect prediction is believed to be coverage bias: respondents were recruited primarily from the telephone directory and a register of car owners, which resulted in more wealthy people being sampled than less wealthy. There was also a low response rate and non-response bias (see for example: Squire, 1988).

them. But also their *predictive stability* has been shattered in the last decade, even though rhetorical closure regarding its theoretical superiority remains intact.

3.1.3 Why so late?

In election forecasts, the voting intention of a subsample of the population serves as a proxy to understand the voting intention of a population and to tap into public opinion. The possibility of making statements about a population based on a sample, i.e., a small part of the population is still relatively young: while sampling was first proposed in the 17th and 18th century by people like John Graunt, William Petty, and Pierre Simon Laplace, it remained largely rejected until it was (again) seriously proposed at the beginning of the 20th century. As I explore in greater detail elsewhere (Griessl, 2022, forthcoming), the 19th century epistemic context was one that saw sampling as speculative and uncertain knowledge, prioritizing full enumeration instead. The central figure in the development of sampling is the Norwegian Anders Nicolai Kiær, who, in 1895, presented his idea of the ‘representative method’ during the conference of the International Statistical Institute in Bern. His suggestion of a “partial exploration with observations on a large number of scattered localities, distributed over the whole territory so that they form a miniature of that whole“ (Kiær in: Kruskal and Mosteller, 1980: 176), was first met with great resistance. In Griessl (2022, forthcoming), I show how this suggestion was followed by a set of rhetorical figures that can be considered as a practice of boundary work (see: Gieryn, 1983; Jasanoff, 1995) by fellow statisticians, who called his approach unserious and dangerous, claimed the terrain of epistemic authority as one that only grants full enumeration the label of science, demarcating it from the apparent unscientific method of sampling. This „communally approved drawing of lines between ‚good‘ and ‚bad‘ work (and, not trivially, between good and bad workers) within a single discipline “ (Jasanoff, 1995: 53), however, became more and more difficult to maintain. It took until 1925 that Jensen, who reported on the 1925 ISI congress, stated that while in the beginning, the ISI was mainly concerned with the „recognition of the method in principle“ (Jensen et al., 1926: 59) there are now hardly any statisticians „who in principle will contest the legitimacy of the representative method“ (ebd.). A central figure in this context was Sir Arthur Bowley, who not only defended Kiær’s approach, but also further developed it by suggesting randomization as a means to select a sample in contrast to Kiær’s purposive selection procedure. At this point, the question within the community was not about whether or not sampling was appropriate, but about which sampling approach to follow. The controversy was about whether randomization or purposive selection was key to solid inference. After the publication of Neyman’s (1934) famous paper, randomization eventually became the superior approach to sampling and the controversy reached closure.

3.1.4 Some Notes on Closure

Theories of closure were famously developed by Pinch and Bijker (1984), drawing a picture of technology shaped almost exclusively by social processes. The basic assumption behind this is that stabilized technologies are always the result of long and complex social processes and negotiations. Following this line of thought, both science and technology can be investigated in terms of their socially constructed nature and the social patterns and mechanisms that are effective in the process. This approach became known as SCOT (Social Construction of Technology). Among the forms of closure, Pinch and Bijker (1984) suggest two forms of closure: rhetorical closure, which, in the area of science relates to "some 'crucial' experimental result, 'definitive' proof or 'knockdown' argument which has the effect of closing the debate on some controversial issue" (Pinch and Bijker, 1984: 425). Those results may not convince the scientist from the "Core-Set", but rather the wider community. The second form is closure by redefinition of the problem. In this case, a controversy can be stabilized when the technology in question is being used to solve a different problem. Closure is reached through "redefining the key problem with respect to which the artefact should have the meaning of a solution" (Pinch and Bijker, 1984: 428).

Drawing on those ideas, the consensus reached regarding the superior sampling methods can be called 'rhetorical closure', relating to "some 'crucial' experimental result, 'definitive' proof or 'knockdown' argument which has the effect of closing the debate on some controversial issue" (Pinch and Bijker, 1984: 425). Closure refers to the phase in which a technology or technical artefact acquires a stable identity, in which controversies around how it ought to look like come to an end. In those phases of closure, consensus emerges among scientists and practitioners. Closure, however, does not need to be permanent. The achieved stable identity can turn out to be inadequate for a certain purpose and bring about new developments and reorientations.

When looking at the use of sampling in election forecasts, the story looks slightly different than the history of sampling might suggest. As we have seen in the previous section, the wide adoption of random sampling was not employed after 'rhetorical closure' had been achieved, it happened when the *predictive stability* of other forms of sampling became fragile, when a stable network dissolved. Epistemic closure was reached after the embarrassing miscalls in the course of the 1936 and especially the 1948 elections.

3.2 There is no Election on Public Opinion

Looking at the 1948 election and the controversies it sparked, we can make more sense of the two classes of how polls are perceived, as outlined before: polling without predictive content and polling with predictive content. As already stated, the Gallup poll enjoyed a lot of trust due to its successful track record. Some months before the 1948 election, Gallup stated that public opinion polling methodology became highly successful and reliable.

> "The reliability of methods now employed to gauge public opinion has been demonstrated time and again, not only in the United States but in a dozen different nations. Polls have met successfully the test which any scientific method must meet. They have proved equally reliable when applied in completely different circumstances and by different organizations. […] Modern poll procedures make it possible to conduct a nationwide referendum or plebiscite in a matter of hours, and to report results that would differ by only a few percentage points from the results which would be obtained if the entire voting population of a nation went to the polls. In fact in many situations - particularly those in which a substantial portion of the population fails to take the trouble to vote - the poll results might be even more accurate as a measure of public sentiment than the official returns." (Gallup, 1955: 20–21)

Interestingly, the editors deemed it necessary to add that Gallup made this statement "just a few months before he and his fellow pollsters found themselves under terrific pressure because of their failure to forecast correctly the election of President Truman in November, 1948". In the aftermath of the 1948 election, Gallup made a slightly less confident statement during a symposium on the question of whether public opinion polls should make election forecasts. He stated that polls are always subject to probabilities and also prone to fail, but that pollsters will give their best and continue to improve their methods.

> "With the same certainty that we know we can be right most of the time, we know that we will be wrong some of the time. It has to be that way. We live by the law of probabilities. We will do our best to improve our methods and to do better the next time." (Gallup in: Seymour et al., 1949: 141)

After his statement during the symposium, Gallup was asked a question regarding the purpose of political polling on the background that it wastes a lot of time and energy only in order to see "who is going to get the election when you will know in a few weeks anyway" (in: Seymour et al., 1949: 142). Agreeing with the questioner on the little social value to election forecasting per se, he justified it as a means to test polling methods:

> "It has been my experience that we have had a greater urge, we have done more to perfect our methods, we have actually made greater progress because we knew we were going to have to face an acid test, than we probably would have made if we hadn't been making election forecasts. So I think the only justification of an election forecast is to test polling methods." (Gallup in: Seymour et al., 1949: 143)

What Gallup states here is highly interesting. In the case of, for instance, the famous toothpaste of British men or the public opinion on introducing a speed limit on German motorways, there is nothing out there based on which the truth of such a survey can be measured, except for maybe another survey. In the case of election forecasting, on the other hand, one can say whether or not the polls pointed toward the right direction. This is where the difference between polling with and polling without predictive content becomes relevant. When considering the history of election forecasting and the history of sampling, it becomes apparent that new sampling methods were not widely adopted by pollsters after their superiority has been theoretically shown by survey methodologists; new sampling methods were rather adopted after shortcomings became evident in the aftermath of election forecasts.

The introduced distinction between polling with predictive content and polling without predictive content comes to the fore here, and we see how the evaluation of the methods of the former can lead to an evaluation of the methods of the latter. Thus, polling with predictive content informs polling without predictive content.

4 Rethinking Closure as Ceremony

4.1 The Formation of a New Network: Enrolling the Non-Respondent

In recent years, maintaining probability (random) based surveys has become more and more difficult and expensive. One of the main reasons for this is that telephone surveys suffer from ever greater non-response, which leads to higher costs and a possible bias in the sample. Figures from the Pew Research Center show that while response rates were still at 36% in 1997, they were at only around 6% in some cases in 2018 and the trend is continuing to decline (Kennedy and Hartig, 2019). This difficulty of capturing public opinion that comes with the dissolution of landline phones and increasing non-response is related to what might be called 'ontological ignorance', a "way of not-knowing that hinges on the particular orderings, the being of the world" (Marquardt, 2016: 3). This is why it has become necessary to increase efforts to reach mobile phones, to use statistical tools to adjust for biases and to tap into public opinion through the internet. The development of the internet brought about new solutions to the problem that there are much more non-respondents than respondents in telephone surveys.

As Bethlehem (2018) shows, conducting surveys online, usually referred to as computer-assisted web interviewing (CAWI), has a history that traces back to the mid-1990s century, when HTML 2.0 became available. Different to HTML 1.0 and E-Mails, this allowed for the transmission of data from the computer of a potential interview partner to the server of the researchers. Whilst E-Mail polls were already experimented with in 1983 (see e.g., Sproull and Kiesler, 1986), the year 1995 and the introduction of HTML 2.0. marks the beginning of web polls and online sampling. Conducting surveys online offers a cheap and fast way to collect large numbers of responses and has thus been very attractive to researchers right from the beginning.

It, however, also evoked strong criticism right from the start, as it turns a basic principle of survey research on its head. The principle is that it must not depend on the individual whether they enter the sample, but that the probability to enter a sample must be the same or known for each person that belongs to the population for which the results are to be generalised. This is the principle that guides polling and survey research at least since the late 1940s when it became apparent that not following this principle can lead to enormous failures. Conducting polls and surveys online does not necessarily mean that the principle of probability sampling needs to be overthrown. Most online surveys, however, are non-probability based, which means that respondents usually chose to participate themselves, which runs the risk of leading to a highly self-selected sample. This is why adjusting the data in a way that it becomes representative of the target population is a central part of polling as conducted today. In this sense, the shift to non-probability samples not only constitutes a change in the tools through which public opinion is captured; it evokes a different epistemological grid: Whereas in the case of probability sampling, public opinion polling relies on the existence of a list of people from which a sample can be randomly selected (e.g. phone books or randomly generated phone numbers, in the case of online non-probability sampling, no such list exists (there is no list of all E-Mails, nor is it possible to randomly generate E-Mail addresses). This reflects a broader shift in the understanding of what it means to represent public opinion, one from being chosen to enter a sample to choosing to enter a sample. It is through this reordering, through which the non-respondent could be reintegrated into the polling apparatus and new practices of knowledge creation could start to be formed. But as is the case with traditional methods, also the more recent methods are not yet ripe to produce predictive stability.

4.2 No Closure in Sight yet

It is common knowledge that the last decade has seen an upsurge in headline-making mispredictions by pollsters when it comes to high-profile elections and referendums. Most prominent among these are the US elections of 2015 and 2020, as well as the British House of Commons election of 2015 and the Brexit referendum of 2016. These are reminiscent of the miscalls in 1936 and 1948 and may a century from now be treated in the same paradigm-shifting way that Gallup’s famous triumphs and failures back then are now treated. Following these mispredictions, many investigations were carried out to explore why such sometimes severe miscalculations occurred. In the case of the 2015 British House of Commons election, for example, Sturgis et al. (2018) concluded that the main reason for the misprediction was a strong bias in the samples. All election forecasts were based on non-probabilistic methods: They concluded that the main reason for the polling miss were "samples which were unrepresentative of the target population's voting intentions“ and that “these biases were not mitigated by the statistical adjustments that pollsters applied to the raw data" (Sturgis et al., 2018: 760). In the case of the 2020 US election, however, something different may be observed. Under the title "Revisiting the 'goldstandard' of polling: new methods outperformed traditional ones in 2020", Enns & Rothschild (2020) concluded that non-probabilistic methods performed better than probabilistic ones. They ascertain that the vast majority of election surveys were non-probability samples, but different than in the 2015 British House of Commons election, they could not show that “less expensive, opt-in sample hurt polling accuracy”. On the contrary, they show that “[n]on-probability surveys and surveys combining probability and non-probability methods outperformed probability-based surveys“ (Enns and Rothschild, 2020). If *predictive capacity* was the primary way of achieving closure, probability and non-probability methods seem to be currently roughly on par. The networks in and through which *predictive stability* can be achieved, however, are not yet formed.

4.3 Stabilising Ceremonies

An established network implies closure in the sense that it prevents other actors and relations to enter the network, allowing for the accumulation of scientific knowledge. Considering the history of election forecasting, it can be observed that closure was not achieved through some "'crucial' experimental result", but rather after an approach reached *predictive instability* in the sense of a societal shared expectation that predictive claims do not necessarily point towards the right direction. Historically, those moments led to a reconsideration of used approaches, something that can also be observed in contemporary debates around sampling. Furthermore, one might say that the way how the polling network gets stabilized often runs through particular ceremonial forms of closure. In the immediate aftermath of elections, the question as to how well different polling institutes and approaches fared has become a routinised practice. The evaluation of polls after elections constitutes the precise moments in which links between the media, the public, polling organizations and others are getting stronger or weaker. It is through these processes that the various actors are put in their place and the networks become more and more (de)stabilized.

5 Conclusion

Throughout this essay, I reconstructed the development of a culture of prediction in election forecasting alongside the history of statistical sampling. This presentation was embedded in a broader discussion around cultures of prediction in the social sciences, arguing that it is precisely because of the metaphysical impossibility of predicting future states in open systems like elections that strong and stable cultures form around predictive claims. In this sense, I coined the notion of predictive (in)stability to conceptualize the assembling and disassembling of the heterogenous network behind the making of predictive claims in this field. This notion can become fruitful as a way to think about further aspects surrounding predictive claims in the social sciences. It can help illuminating, for instance, which groups or individuals have the authority to speak about the future, how are those claims maintained despite their intrinsic uncertainty, what practices exist to challenge and weaken predictive claims or who are the groups and individuals who (dis)trust predictive claims. Those kinds of questions surround the field of cultures of prediction and can inform Heymann et al.'s (2017) five dimensions that characterize cultures of predictions, including their social role, the character and significance of computational practices, the domestication of uncertainty, the degree of institutionalization and professionalization of predictive expertise and the cultural impact of predictive practices and claims.

As has been indicated throughout this essay, predictive claims in election forecasting seem to struggle in assembling stable cultures in recent years. Famous election miscalls, general declining trust in statistics and increasing difficulties to maintain polls and surveys lead to attempts to develop new methods to tap into public opinion and forecast election outcomes. The question of which methods will be able to assemble stable cultures of prediction is open and will depend on many things that need to be put in their place.

6 Bibliography

Bethlehem J (2018) Understanding Public Opinion Polls. CRC Press.

Collin F (2014) Who Are the Agents? Actor Network Theory, Methodological Individualism, and Reduction. In: Rethinking the Individualism-Holism Debate. Cham: Springer International Publishing, pp. 197–217. DOI: 10.1007/978-3-319-05344-8_11.

Diaz-Bone R and Horvath K (2021) Official statistics, big data and civil society. Introducing the approach of “economics of convention” for understanding the rise of new data worlds and their implications. Statistical Journal of the IAOS 37(1): 219–228. DOI: 10.3233/SJI-200733.

Enns PK and Rothschild J (2020) Revisiting the ‘ gold standard ’ of polling : new methods outperformed traditional ones in 2020. medium.com.

Fine GA (2007) Authors of the Storm: Meteorologists and the Culture of Prediction. Chicago: University of Chicago Press.

Gallup G (1955) The Role of the public opinion poll. In: Free Press and Society/Ed. by G. Bird, F. Merwin. New York: Prentice-Hall, p. 20.

Gieryn TF (1983) Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists. American Sociological Review 48(6): 781. DOI: 10.2307/2095325.

Griessl L (2022) Zwischen Konsens und Kontroverse: Grenzarbeit in der Geschichte der Stichprobe (forthcoming).

Guala F (2015) Philosophy of the Social Sciences (ed. P Humphreys). Oxford University Press. DOI: 10.1093/oxfordhb/9780199368815.013.6.

Hacking I (1999) The Social Construction of What?

Heymann M, Gramelsberger G and Mahony M (eds) (2017) Cultures of Prediction in Atmospheric and Climate Science. Routledge. DOI: 10.4324/9781315406282.

Jasanoff S (1995) Science at the Bar: Law, Science, and Technology in America. Cambridge, MA: Harvard University Press.

Jensen A, Saenger K and Bowley AL (1926) Rapport de M. Jensen sur l'Application de la méthode représentative. Bulletin de l'Institut international de statistique 22: 58–61.

Katz D and Cantril H (1937) Public Opinion Polls. Sociometry 1(1/2). [American Sociological Association, Sage Publications, Inc.]: 155–179. DOI: 10.2307/2785264.

Keller F (2001) Archäologie Der Meinungsforschung. Konstanz: UVK Verlagsgesellschaft mbH.

Kennedy C and Hartig H (2019) Response rates in telephone surveys have resumed their decline. Pew Research Center. Available at: https://policycommons.net/artifacts/616911/response-rates-in-telephone-surveys-have-resumed-their-decline/1597639/.

Knorr-Cetina K (1999) Epistemic Cultures : How the Sciences Make Knowledge. Harvard University Press.

Kruskal W and Mosteller F (1980) Representative Sampling, IV: The History of the Concept in Statistics, 1895-1939. International Statistical Review / Revue Internationale de Statistique 48(2): 169. DOI: 10.2307/1403151.

Latour B (1996) On actor-network theory: A few clarifications.: 369–381.

Likert R (1948) Public Opinion Polls. Scientific American 179(6): 7–11.

MacKenzie DA (2006) An Engine, Not a Camera: How Financial Models Shape Markets. Inside technology. Cambridge, Mass: MIT Press.

Marquardt N (2016) Counting the countless: Statistics on homelessness and the spatial ontology of political numbers. Environment and Planning D: Society and Space 34(2). SAGE Publications Ltd: 301–318. DOI: 10.1177/0263775815611421.

Merton RK (1948) The Self-Fulfilling Prophecy. The Antioch Review 8(2). Antioch Review, Inc.: 193–210. DOI: 10.2307/4609267.

Neyman J (1934) On the Two Different Aspects of the Representative Method: The Method of Stratified Sampling and the Method of Purposive Selection. Journal of the Royal Statistical Society 97(4): 558–625. DOI: 10.2307/2342192.

Northcott R (2015) Opinion Polling and Election Predictions. Philosophy of Science 82(5): 1260–1271. DOI: 10.1086/683651.

Pinch TJ and Bijker WE (1984) The Social Construction of Facts and Artefacts: or How the Sociology of Science and the Sociology of Technology might

Benefit Each Other. Social Studies of Science 14(3): 399–441. DOI: 10.1177/030631284014003004.

Seymour G, Crossley A, Lazarsfeld PF, et al. (1949) Should Public Opinion Polls Make Election Forecasts?: A Symposium. Journalism Quarterly 26(2). SAGE Publications: 131–144. DOI: 10.1177/107769904902600201.

Smith TW (1990) The First Straw?: A Study of the Origins of Election Polls. Public Opinion Quarterly 54(1): 21. DOI: 10.1086/269181.

Soros G (2013) Fallibility, reflexivity, and the human uncertainty principle. Journal of Economic Methodology 20(4): 309–329. DOI: 10.1080/1350178X.2013.859415.

Sproull L and Kiesler S (1986) Reducing Social Context Cues : Electronic Mail in Organizational Communications Author (s): Lee Sproull and Sara Kiesler Published by : INFORMS Stable URL : http://www.jstor.org/stable/2631506 Accessed : 01-03-2016 17 : 01 UTC Your use of the JSTOR arch. Management Science 32(11): 1492–1512.

Squire P (1988) Why the 1936 Literary Digest Poll Failed. Public Opinion Quarterly 52(1): 125. DOI: 10.1086/269085.

Sturgis P, Kuha J, Baker N, et al. (2018) An assessment of the causes of the errors in the 2015 UK general election opinion polls. Journal of the Royal Statistical Society: Series A (Statistics in Society) 181(3): 757–781. DOI: 10.1111/rssa.12329.

Solar Energy Prosumption in Fruit Value Chains Support the Energy Transition

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Abstract. The objective of the present study was to assess the potential of reducing carbon emissions from on-farm energy use for fruit storage. For this case study, we developed a model fruit farm, where apples are produced, then stored for up to six months and sold on the local market. We calculated the primary energy demand and the carbon footprint of solar versus national grid energy to operate the fruit storage. We determined the extent to which the use of solar energy would contribute to the decarbonisation of the fruit value chain at the farm level under the given energy requirements. In our study, we compared the carbon footprint for two scenarios: Use of i) self-generated solar electricity and ii) grid electricity.
The main challenge when considering the use of solar energy is that energy is needed for the storage facility in winter, when the yield from solar energy is lowest, and a high yield from solar energy is achieved in summer, when the energy demand on the farm is comparatively low. This is true not only for fruit farms, but they represent one of the most energy-intensive forms of agricultural production.
We argue that while the use of alternative energy sources compared to the normal grid has a positive environmental impact on reducing carbon emissions, the temporary gaps in solar energy production and demand contribute significantly to farmer uncertainty. Based on our calculation we can show, that there is most probably no additional financial burden on farmers.

Keywords: Apple; fruit storage; green energy; sustainability; solar panel

1 Introduction

In order to support the energy transition and reach the goal of achieving an energy supply with low carbon emissions by 2050 at the latest, a leverage point in the pome fruit value chain is to sustainably procure the energy to operate the storage facilities of pome fruit. Until a few years ago, the principle of using the sun for growth on a farm was limited to growing crops, but due to technological advances and rising energy prices, it is becoming more and more interesting for farmers to also think about using the sun to produce the energy needed for the processes on the farm from field until the farm gate. To combine the production and consumption of a resource at the same location can be associated with several benefits. It is important to have a look at the farmlevel and its potential for energy prosumption due to the availability of un- or underused spaces e.g. on roofs. Alvin Toffler coined the term *prosumer* in 1980 for individuals who simultaneously assume the role of both consumer and producer, partially or completely (Toffler, 1980). Our study considers the sustainability potential for energy prosumption in the fruit value chain at the farm level.

In this case study, we designed a model fruit farm in Germany with apple as the dominant crop as an example and investigated its potential in terms of CO_2 savings and financial benefits in the event that alternatives to the conventional power grid are used for energy supply for fruit storage. In Europe, apples are one of the most cultivated fruit crops with 10-12 million tons per year (Eurostats, 2022). Apples are also an important nutritional source of vitamins and minerals, consumers expect to buy apples all year round for a healthy diet. Therefore, the retailers try to cover the demand in months without domestic or European apple production, especially in the months of May-July, with imports from the southern hemisphere (SH). The three most important apple imports from the southern hemisphere to Germany come from New Zealand, Chile and South Africa, with New Zealand and Chile challenging each other for first place depending on the annually fluctuating yields. In New Zealand exported over 35,000t to Germany, alongside Chile (36,000t) and South Africa (10,000t) showing the slight yearly variations depending on the season (Statista, 2022). The harvest on the SH begins in February, so apples from the south can be made available directly after transport from April without energy-intensive storage.

Previous studies have shown (Blanke and Burdick, 2005; Milà i Canals et al., 2007; Frankowska et al., 2020) that it is highly advisable for consumers, to source regionally cultivated apples and other fresh produce locally for most of the year. The calculations of the primary energy demand of domestic apples have shown that the energy balance of domestic and marketed apples from October to April is more favorable from a sustainability point of view than that of imported apples from the southern hemisphere. This is despite the energy required for storage, which is the most energy-intensive process in the supply chain to keep the local fruit in good quality and marketable condition for an extended period of time. But there is a challenge between consumers demands and producers possibilities, most local pome fruits in the North are already consumed by the end of April and cannot meet consumers demands.

To maintain all year-round fruit supply, local apple can be stored after harvest, from October to April in the northern hemisphere (Koca, 1993; East et al., 2013) and are complemented with apples from the south from April until the beginning of the harvest in August. The apple storage is under a controlled atmosphere (CA) of 1-3 % CO_2 and 1 - 3 % O_2 at temperatures of 1-3°C (Yost, 1984; Doerflinger et al., 2015) and requires 0.81 MJ/kg primary energy for 7 months (~0.172 MJ/kg/month) thereby contributing ca. 20-30% to the overall energy balance of the product (Blanke and Burdick, 2005). When harvesting in the global south begins in February and apples harvested there are on sale in Europe from April, conditions change from April onward in two ways. First, stored stocks of domestic apples begin to run low, and second, the energy required to store apples adds up to be comparable to the energy required to transport imported apples. This energy ratio of imported to domestic apples remains even if one assumes technical efficiency gains, which experts estimate to be about the same for both variants (pers. comm.). Thus, the absolute numbers may have changed over the past 15 years, but the ratio of primary energy consumption is still comparable. The question therefore arises as to whether and how the energetically more favourable supply of regional products can be maintained for longer.

While the primary energy balance could be improved by the installation of energy-saving equipment for cooling and storage of fruit or an innovative storage regime which works with higher storage temperatures and optimized ventilation of the storage chambers (Kittemann et al., 2015; Neuwald et al., 2015), we argue that the carbon footprint of the energy used can be reduced by a sustainable choice of the energy source.

Assuming that a more favourable CO_2-balance can be achieved for the same primary energy requirement for apple storage by switching to e.g. solar energy, the eco-balance of regional fruit could also be more favourable than that of imported fruit in the harvest months in the southern hemisphere. We therefore compare the carbon footprint of local apples with the carbon footprint of imported apples from New Zealand, depending on the energy source for the storage facilities. Our approach also calculates the potential savings of fossil energy from the German power grid on regional fruit farms through the use of photovoltaic systems (PV) on the roofs of the fruit stores and the potential savings on CO_2 due to the use of green energy.

While many farmers are interested in more sustainability and want to use sustainable energy sources for fruit storage, they can be hesitant due to the uncertainty of if and when the investment will ever pay off. Therefore, another objective of the present work is to give an estimate of the expected net financial gain of using solar panels for a more sustainable horticultural production. Probabilistic decision analysis approaches are used ex-ante in cases of decisions with high uncertainty and risk in the presence of poor or insufficient data to provide a more accurate estimate of the risk and likely outcomes of the decision (Luedeling and Shepherd, 2016; Do et al., 2020). We use a probabilistic decision analysis approach to estimate the investment risk for the farms.

It is our hypothesis that the use of green energy for the storage facilities can significantly contribute to further improving the overall carbon footprint of regionally grown and locally consumed fruit and contribute to the income of the farms.

In summary, the study examines the role of farmers’ sustainable decision making and how the farm and the society alike might benefit from a good outcome of the decision. Two scenarios compare the impact of replacing the energy source for the necessary processes on a fruit farm and its implications for the carbon footprint of the final product, domestic apples with i) grid energy vs. solar energy ii) domestic apples in fruit stores powered by solar energy versus imported apples from overseas. The findings can be used to provide substantial producer and consumer information and guide social actors to make more sustainable choices.

2 Materials and Methods

2.1 Conceptualising the model fruit farm

We designed a model farm located in the Rhineland growing region of Germany, producing for domestic demand (Table 1). The system's boundaries were set around the post-harvest and storage (Figure 1). The model fruit farm was designed according to the average values for the Rhineland region (Table 1), its apple acreage was taken from the German Federal Statistical Office (DESTATIS, 2017). The data refer to the status as of 2017, the year of the fruit tree census, which will only be updated by the end of 2022 at the earliest. Apple yields per hectare from the state office of North Rhine Westphalia were averaged over 5 years (2015-2020) as basis for the required CA storage capacities, assuming that the storage capacity is 10% in addition to that required for storage of the average annual harvest volume. The roof areas of randomly selected farms in the Rhineland were measured on maps available online. Based on the requirements of the calculation tool PVGIS regarding orientation and inclination, the percentage of roof area suitable for PV systems was estimated. On this basis, it was determined that each farm in the Rhineland would have at least 1000 m² of suitable roof area. With an efficiency of 20%, the construction of a PV system with 200 kWp would be possible for the farms. The goal is to investigate what proportion of the electricity needed to store the apples can be covered by the solar system during the 7-month storage period.

Table 1: Data for the model fruit farm in Rhineland region (Germany)

Parameters	Value
Latitude [°N]	50.6
Apple production area [ha]	16.9
Yield per unit area [t/ha]	32
Yield per unit time and farm [t/a]	540.8
PV-usable rooftop area [m²]	1000
CA storage capacity per farm [t]	600
Nominal capacity of PV system [kWp]	200

2.2 Flowchart and system boundaries

For the primary energy analysis, we focus on post-harvest processes on farm. The system boundaries of the present investigation exclude all other energy requirements e.g. during fruit production and all steps necessary after storage until marketing to the end-consumer (Figure 1). The primary energy analysis (PEA) includes all stages from after harvest to the end of the storage period. The present investigation and energy requirement starts from freshly harvested apples at ambient orchard temperature (14-18°C), which need to be pre-sorted and then cooled down to the final storage temperature (1-3°C). For the imported apples from overseas (New Zealand), all energy requirements starting from cooling down, followed by transport from overseas until unloading in Antwerp until the transport to the Rhineland in Germany are included in the calculation.

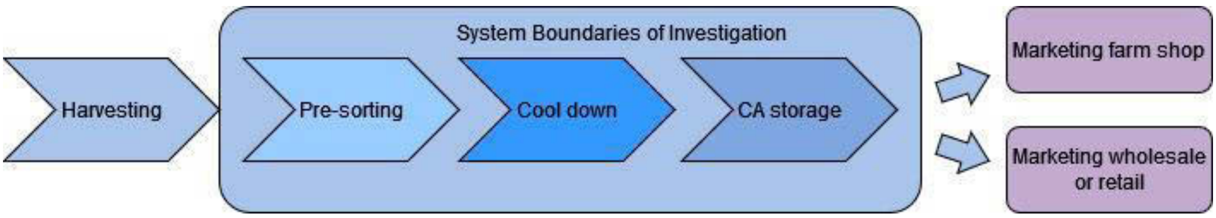

Figure 1: Flow chart and system boundaries of the primary energy analysis beginning with pre-sorting, followed by cooling down and CA storage of apples.

2.3 Global radiation

Global radiation was chosen as the reference and one of the possible energy sources for fruit storage because global radiation varies with the angle of inclination of the sun and therefore depends on the season and the latitude of the location. With the analysis we focused on the location of Meckenheim/Rhineland, Germany at 50.6°N. We have retrieved the measurement data for all years available (2005-2020) for our location in the European Commission's science and knowledge service with its Photovoltaic Geographical Information System (PVGIS, 2022) which encompasses all wavelengths

(200 - 4000 nm) without overemphasizing any particular wavelength as in the case of PAR (400-700 nm) as the basis for generating photovoltaic energy.

2.4 Photovoltaic energy production

PVGIS was employed to calculate the performance of a 1000 m² grid-connected, mono-crystalline silicone, fixed angle roof-top photovoltaic system with an optimized slope of 35° for our location and a radiation use efficiency of 20% with a nominal power of 200 kWp and a default system loss of 14%.

2.5 Carbon footprint calculation for different energy sources

We assume that the different electricity sources for the storage or cooling system of the apples (grid electricity, solar electricity and heavy fuel oil) have different impacts on the carbon footprint of the product. To calculate these, we used data from the German Federal Environment Agency to calculate the emission factor for the German electricity mix (BMU, 2021) with emissions of 101-111g CO_2-eq/MJ. Due to the difficulty in calculating future policy developments, which envisage long-term fossil fuel reductions for grid electricity generation but do not currently propose a solution to bridge the supply gap, we assume for the calculation that CO2 emissions will decrease by an average of 10% over the next 20 years, as they have in the past. To assess GHG emissions from solar energy, we used the Federal Environment Agency's values of 9.7-15.5 gCO_{2e}/MJ (BMU, 2019). Emissions from solar energy do not occur during operation, but through the production and disposal of the modules. We estimate the values for a PV system made of monocrystalline silicon and an efficiency of 20%. For the calculation of heavy oil emissions, we used data from the German Federal Environment Agency of estimated 79.6 to 81.3 g CO_{2e}/MJ (UBA, 2016) (Table 2). The emissions result from the combustion of heavy fuel oil for ship transport and for energy generation for the reefer containers. The energy demand for the storage of local fruit in the months October to April (181 days) and for the transport and storage of imported fruit from New Zealand (transport distance 23,000 km) is taken from Blanke & Burdick (2005).

Table 2: Values for the carbon footprint calculations

Source	Minimum	Average	Maximum	Unit
CO_{2e} emissions for solar energy	9.7	n.a.	15.5	gCO_{2e}/MJ
CO_{2e} emissions for German grid electricity mix	111.4	n.a.	130.0	gCO_{2e}/MJ
CO_{2e} emissions for heavy oil combustion	79.6	n.a.	81.3	gCO_{2e}/MJ
Energy demand for storage of local fruit	n.a.	977.4	n.a.	MJ/t
Energy demand for transport imported fruit	n.a.	2836	n.a.	MJ/t

2.6 Primary energy analysis

Primary energy values originate from Blanke and Burdick (2005) of 0.81 MJ/ kg apples stored under CA conditions for 7 months (~0.172 MJ/kg/month), thereby contributing approximately 30% to overall energy balance of 5.8 MJ/kg home-grown apples in the Meckenheim fruit growing region of Germany (50.6°N). The pre-cooling can account for a 30-45% increase in energy consumption in the first month, equivalent to 86kJ/kg (Blanke and Burdick, 2005). For the apples from overseas the data regarding the primary energy demands were taken from literature (Blanke and Burdick, 2005).

2.7 Calculation of the profitability of the PV system

The R package decisionSupport (Lüdeling et al. 2021) was used to calculate the net present value (NPV) representing the net financial gain for the decision of the model fruit farm (Table 1) to install and run a 1000m² mono crystalline silicon, fixed angle roof-top PV system with east-west orientation for the time period of 20 years. Data were taken from literature, short expert interviews and PV system cost estimates.

3 Results

3.1 Global radiation at Meckenheim, Rhineland

The fluctuation of the available global radiation during the winter months at Meckenheim, Rhineland (50.6°N) was calculated. Different radiation intensities over the course of the year with the fluctuations over 16 years in the years 2005-2020 as calculated by the PVGIS tool have been identified and quantified.

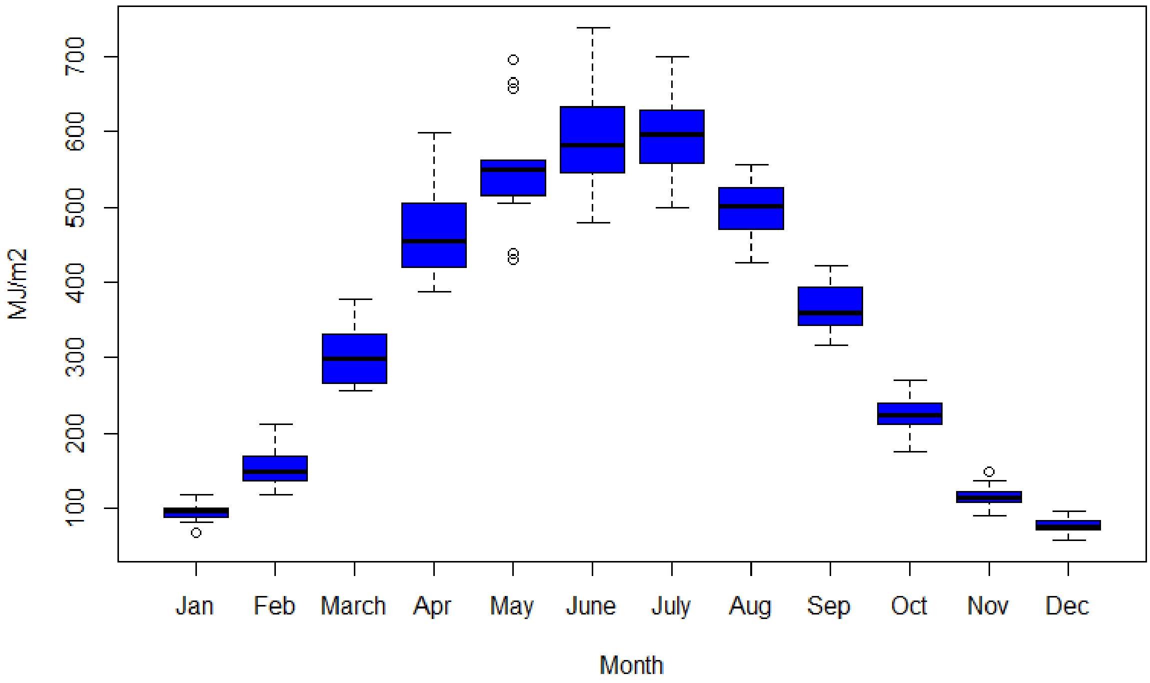

Figure 2: Monthly global radiation (MJ/m²) between 2005 and 2020, computed for 50.6°N, Meckenheim/Rhineland, Germany (Data PVGIS 2022, own visualisation).

3.2 Comparison of energy production and demand

The solar energy generation potential was calculated from the global radiation on a PV system of 1000 m², with a radiation use efficiency of 20% given a fixed angle grid-connected monocrystalline rooftop photovoltaic system with an estimated nominal power of 200 kWp and an estimated system loss of 19.5% due to losses in cables and power inverters as well as due to suboptimal temperature and irradiation. Based on the measurements of the global radiation, the potential energy production per month with a PV system on the roof of the warehouse was calculated (Figure 3).
The values are shown with the double standard deviation added and subtracted from the mean to show the upper and lower boundary for a confidence interval of 95%. The data show a wide distribution of energy values. This means a high level of energy fluctuation and supply uncertainty for the farms which must be compensated for by a power supply via the electricity grid (Figure 3).

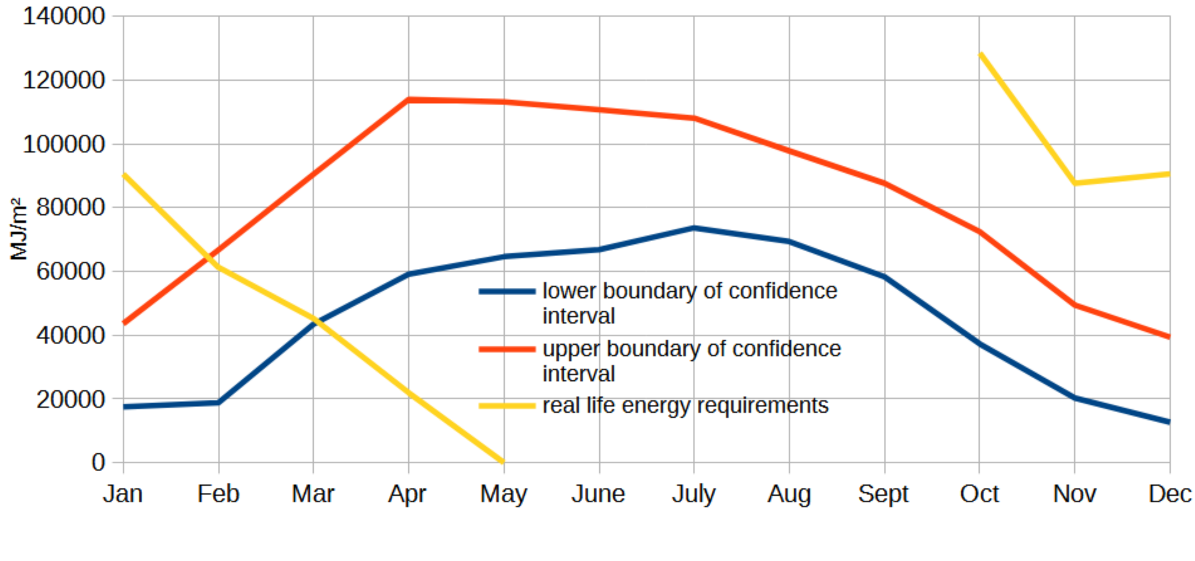

Figure 3: Monthly energy output from a PV system (MJ/m²) with 200kWp in the Rhineland with asynchronicity in solar energy production and theoretic energy requirements for the apple storage facilities. Given is the average monthly energy production (arithmetic mean 2005-2020) + double standard deviation for the upper/ lower boundary of the confidence interval (data PVGIS 2022, own visualization).

Based on the natural solar cycle in the northern hemisphere solar energy production has a plateau in late spring and summer from April to September, decreases then until the minimum in December and increases from the minimum to reach the plateau in April again. The apple storage facilities need the energy at the peak in October for cooling down the entire harvest. For keeping the stored fruit at 1-3°Celsius and under a controlled atmosphere (CA) of 1-3 % CO_2 and 1-3 % O_2, during the months October until April, a constant amount of energy of 0.172 MJ/kg/month apples (Blanke & Burdick, 2005) is needed. From April, domestic supplies begin to run low, and the CA storage rooms are not used until October at the earliest, once the apple harvest is complete. So that between May and October no energy is needed for storage. Global radiation declines from 220 MJ/m² in October to a minimum of 76 MJ/m² in December with a subsequent increase to 469 MJ/m² in April. This is reflected by a decline of energy production from October to December and an increase from December to March (Figure 3). A deficiency of solar energy production during the entire storing period can clearly be noted. The energy required for CA storage of apple fruit peaks during the first month due to the cooling down phase which requires 0.082 MJ/kg apples in the first three days and adds then to the general energy requirement for storage of 0.172 MJ/kg apples (Blanke & Burdick, 2005).

3.3 Carbon footprint

We calculated the carbon footprint for 1 kg of apples depending on the share of energy that was generated by prosumption on the roof of the fruit store on the model farm for storing apples from October to April (Table 3). We compare the carbon footprint of fruit stored in i) a 100% grid electricity powered storage facility, ii) a partially solar powered storage facility from the own roof (1000m² roof/ 200kWp) and iii) a 100% solar powered storage facility and iv) imported fruit from New Zealand. A 100% solar-powered fruit storage system is theoretically possible, but the basic assumptions of our calculation would have to be adjusted. In concrete terms, this would mean increasing the output of the PV system by expanding the area or using electricity storage, e.g. batteries, to bridge under-supply states. These changes and additions are theoretically possible but are not included in the present calculation.

In summary, the carbon footprint is negatively related to the share of solar energy in the total energy demand. The higher the share of solar energy in the total energy demand, the lower the emissions caused by the energy consumption of the storage facilities. The lowest amount of emissions is therefore be caused by the theoretically 100% solar powered storage facility. The total energy demand in winter in Meckenheim cannot be covered 100% by global radiation if only the assumed minimum roof area of the storage hall of 1000m² is available. In this case, the remaining energy demand must be covered by grid electricity. The CO_2 footprint from this mixed procurement of own electricity (solar) and grid electricity (German energy mix) is the option that causes the second least emissions. Apples stored in a storage powered solely by grid energy cause approximately 1.5 to 2 times the amount of emissions compared to the mixed purchase of energy from the sun and the grid energy. However, this option is still more favourable in terms of emissions than imported goods from New Zealand.

Table 3: Range of calculated CO_{2e} emissions per kg apples depending on the origin of the fruit and the energy source for the fruit storage.

Source	Minimum	Maximum	Unit
CO_{2e} emissions for apples stored in a 100% solar energy powered storage	9.5	15.1	gCO_{2e}/kg
CO_{2e} emissions for apples stored in a solar energy powered storage, covering energy gaps with grid energy	24.0	67.4	gCO_{2e}/kg
CO_{2e} emissions for apples stored in a 100% German grid energy mix powered storage	108.9	127.1	gCO_{2e}/kg
CO_{2e} emissions for apples imported from overseas (NZ)	225.7	231.4	gCO_{2e}/kg

3.4 Financial viability

The financial benefit of the decision to install a PV system under given conditions of the model farm in Meckenheim/Rhineland, Germany (50.6°N) and operate it for 20 years was calculated with the R package decisionSupport (Lüdeling et al., 2021) and the values taken from the literature and own calculations (Annex A).

The probability distributions and the outcome for the decision to refuse installing a PV system and the decision to install it as well as the net present value (NPV) of the decision have been compared (Figure 4). Based on our model, the probable NPV of the installation of a PV system has its maximum closely to a financial benefit of about 250000 € over 20 years minus all investment and operating costs. Here, the annual fluctuations in radiation intensity influence the result much less than the future development of the price for grid electricity. For our case, we calculated a moderate electricity price increase of 2% annually over 20 years.

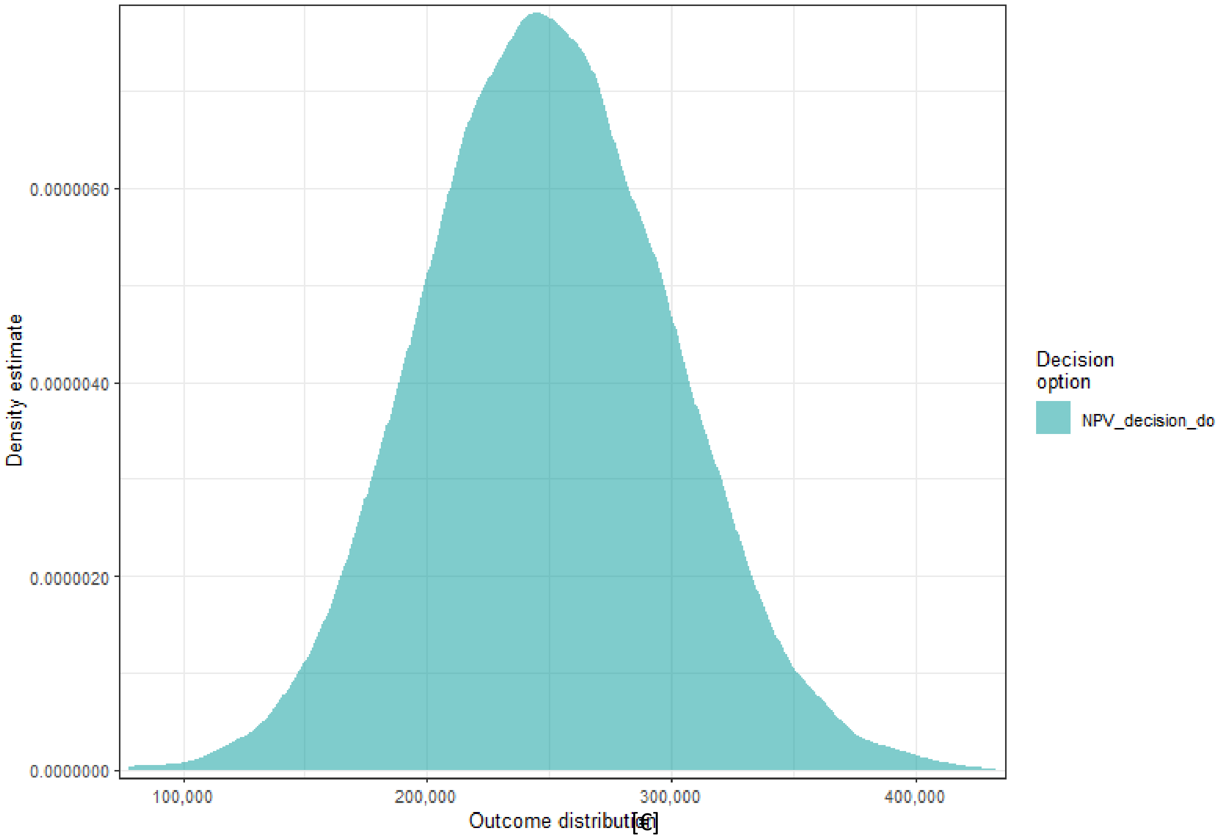

Figure 4: Probabilistic outcome projection for the decision to install a PV system on the rooftop of the model farm. Under the given conditions projected on a time span of 20 years, it can be demonstrated on the basis of the mathematical model that the highest probability is given for a positive result of about 250.000€ for the farm.

4 Discussion

According to our calculations, the fruit value chain can support the energy transition, achieve the goal of a low-carbon fruit supply, and provide additional income to the farm. Our hypothesis was that the use of solar energy for storage facilities can significantly contribute to further improving the overall carbon footprint of regionally grown and locally consumed apples. We found a strong correlation between the carbon footprint and the percentage of solar energy consumed. The higher the percentage of solar energy, the lower the emissions caused by the energy consumption of the warehouses. Our projection shows that 38-81% of carbon emissions can be reduced, so our hypothesis holds true.

Although our calculations are based on data that is 2005, we believe the hypothesis is valid for the following reasons: efficiency gains in refrigeration would be expected in the last 15 years, but there is no published data on this. The reason for this could be that there has been little progress in this regard over the last 15 years. This could be due to generally low energy prices and the lack of a regulatory framework. The experts we interviewed stated that from a technical point of view - if the cooling strategy remains the same in terms of temperature, air circulation, control of gas content, etc. - no major improvements are possible. Only through the farmer's decision to take a higher risk through higher storage temperatures or to invest in the installation of additional fans or sensors would a reduction in energy consumption be possible. The most significant effect could be achieved by increasing the insulation of the cold storage cells. However, this would mean an enormous additional financial burden for the farms. Farmers are therefore essentially guided by the minimum insulation conditions required by law, which have not changed in the last 17 years. We therefore conclude that the 2005 data are still valuable as a basis for calculation.

Whether the reduction potential from energy consumption will remain consistently large in the future depends largely on the design of the German energy mix. The larger the share of renewables and the smaller the share of fossil fuels, the lower the calculated carbon emission savings between own solar power and emissions from grid purchases will be. In the future, we even expect i) more intense global radiation, ii) technological improvements that will lead to better performance of PV systems, and iii) technological advances that will also enable energy savings in fruit storage and storage strategies (East et al., 2013; Neuwald et al., 2015). These developments are very positive and may have a positive impact on the adoption of PV systems and the further reduction of emissions caused by energy consumption on farms.

However, the particular environment of farms should be considered, which affects the implementation options of farms and the installation probability of PV systems. Unlike other economic systems, agricultural production systems are characterized by their strong involvement in and dependence on natural cycles and the resulting high production uncertainty. In our case, we see these uncertainties in the annual variations of available global radiation and in a variation of crop yields. Although many farmers are interested in becoming more sustainable and using sustainable energy sources for fruit storage, they are hesitant due to the uncertainty of if and when the investment will ever pay off. Therefore, the second objective of the present work was to estimate the expected net benefits of using solar panels for a more sustainable production system in horticulture. We used a probabilistic decision analysis approach to estimate the investment risk for farms and to demonstrate the financial viability of the PV system.

Due to certain risks associated with production, storage, and marketing, such as unpredictable weather events like late frost and hail, quality degradation in fruit storage, and fruit price fluctuations, fruit growers need to build financial reserves that are not available for large investments, such as installing a PV system, without creating further risks to the farm. The financial viability of PV systems must be decided on a case-by-case basis. However, our calculations indicate that the installation of a PV system is associated with low risks and large profit opportunities under the selected conditions. In addition, energy prices on the world market are expected to increase, so investing in PV energy may be a profitable option in the future.

Overall, this work has shown that solar panels installed on the roofs of fruit farms are beneficial to both society and the farm. They are able to reduce the emissions caused by the energy consumption of CA storage facilities in winter by 38-81%, thus significantly reducing the carbon footprint of the apple value chain while contributing to the farm's income.

5 Conclusion

Blanke and Burdick (2005) used the primary energy analysis of domestic apples compared to imported apples from overseas to demonstrate that the energy balance was more advantageous until the month of April for the local product. In our analysis, we were able to show that the advantage of the local product can be increased and extended. The key is the source of energy. Where the energy comes from is not irrelevant when we analyse the carbon footprint of the product and the energy costs of the farm. Apples stored in a storage powered by solar energy cause less emissions than apples stored in a storage powered by grid electricity which are still more favourable than apples imported from overseas. In view of the high environmental risks associated with the extraction and combustion of fossil fuels, it is questionable how long society will continue to demand a product that has to be transported over thousands of kilometres on fossil fuel-powered reefers.

Furthermore, the economic analysis revealed a financial advantage for the farms in the Rhineland, although the relationship between production and demand in terms of energy supply seems suboptimal at first glance. We therefore see an enormous benefit for the farms and society and conclude that energy prosumption in the fruit value chain can support the energy transition, provided that the stakeholders concerned receive the right information and make the right decision.

References

Blanke, M., & Burdick, B. (2005): Food (miles) for thought-energy balance for locally-grown versus imported apple fruit. *Environmental Science and Pollution Research*, *12*(3), 125-127. https://doi.org/10.1065/espr2005.05.252

Do, H., Luedeling, E., & Whitney, C. (2020): Decision analysis of agroforestry options reveals adoption risks for resource-poor farmers. *Agronomy for Sustainable Development*, *40*(3), 1-12.

Doerflinger, F. C., Miller, W. B., Nock, J. F., & Watkins, C. B. (2015): Variations in zonal fruit starch concentrations of apples–a developmental phenomenon or an indication of ripening?. *Horticulture Research*, *2*.

Eurostat (2022): Fruit statistics. https://ec.europa.eu/eurostat/web/products-eurostat (assessed 10 March 2022)

East A.R., Smale N.J., Trujillo F.J. (2013): Potential for energy cost savings by utilizing alternative temperature control strategies for controlled atmosphere stored apples. International Journal of Refrigeration. 36: 1109-1117.

Frankowska, A., Schmidt Rivera, X., Bridle, S. L., Kluczkovski, A., da Silva, J., Martins, C. & Reynolds, C. (2020): How home cooking methods and appliances affect the GHG emissions of food. *Nature Food*, *1*, 787-791

Kittemann, D., McCormick, R. & Neuwald, D.A. (2015): Effect of high temperature and 1-MCP application or dynamic controlled atmosphere on energy savings during apple storage. Europ. J. Hort. Sci. 80: 33-38.

Koca R.W., Hellickson, M. L. (1993): Energy savings in evaporator fan-cycled apple storages. Appl. Eng. Agri. 9 (6), 553-560.

Luedeling, E., Goehring, L., Schiffers, K., Whitney, C., & Fernandez, E. (2021): *decisionSupport: Quantitative Support of Decision Making under Uncertainty*. http://www.worldagroforestry.org/

Luedeling, E., & Shepherd, K. (2016): Decision-focused agricultural research. Solutions, 7(5), 46-54.

Milà i Canals, L., Cowell, S. J., Sim, S., & Basson, L. (2007): Comparing domestic versus imported apples: a focus on energy use. *Environmental Science and Pollution Research-International*, *14*(5), 338-344.

Neuwald, D.A., Kittemann, D., Spuhler, M., Rux, G., Linke, M. & Geyer, M. (2015): Optimized air flow in commercial CA storage room of apples. Acta horticulturae 1079: 403-408.

PVGIS (2022) https://re.jrc.ec.europa.eu/pvg_tools/en/; (accessed 12.01.2022)

Statistisches Bundesamt DESTATIS (2017): Baumobstanbau nach Bundesland: https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Landwirtschaft-Forstwirtschaft-Fischerei/Obst-GemueseGartenbau/Tabellen/baumobstanbau-bundeslaender.html (accessed 12.01.2022)

Toffler, A. (1980): The rise of the prosumer. *The Third Wave. New York: Morrow*, 265-288.

Yost G.E. (1984): Energy savings through the use of fan and refrigeration cycling in apple cold storage. Trans. ASAE 27 (2), 497-501

ANNEX A

Table I: Values for the financial viability calculation

unit	description	lower	upper	distribution
MJ/t	Energy consumption for cooldown	86	121	posnorm
€/m²	cost of building a pv system per area	220	250	posnorm
%	Cost of necessary maintenance of PV system per year per area	0.05	0.08	tnorm_0_1
€/MJ	Costs for energy production per MJ (costs of PV system divided by energy production)	0.024	0.024	const
%	discount rate	0.05	0.05	const
MJ/t/d	Energy required for the storage of 1t apples per day	5.4	5.4	const
MJ/m2	energy production per square meter double SD +/-	59.101884	113.886252	posnorm
MJ/m2	energy production per square meter double SD +/-	69.326352	97.746336	posnorm
MJ/m2	energy production per square meter double SD +/-	12.686472	39.313368	posnorm
MJ/m2	energy production per square meter double SD +/-	18.771912	66.692952	posnorm
MJ/m2	energy production per square meter double SD +/-	17.53074	43.569972	posnorm
MJ/m2	energy production per square meter double SD +/-	73.640952	108.038232	posnorm
MJ/m2	energy production per square meter double SD +/-	66.796956	110.638764	posnorm
MJ/m2	energy production per square meter double SD +/-	43.418664	90.462888	posnorm
MJ/m2	energy production per square meter double SD +/-	64.573092	113.1561	posnorm
MJ/m2	energy production per square meter double SD +/-	20.286288	49.375584	posnorm
MJ/m2	energy production per square meter double SD +/-	37.249668	72.415764	posnorm
MJ/m2	energy production per square meter double SD +/-	58.2966	87.609528	posnorm
kWh/t/m	energy consumption per amount per month in an ca system	15	24	posnorm
€/MJ	energy price per MJ from the grid	0.061	0.072	posnorm
%	decrease of energy production capacity per year	0.02	0.05	tnorm_0_1
% / month	percentage of loss per month during storage in ca system	0.1	0.15	tnorm_0_1
a	Time for projecion	20	20	const
ha	production area model farm	16.9	16.9	const
m2	PV system size model farm	1000	1000	const
€/MJ	Solar revenue; money you get for putting energy into the grid	0.014	0.014	const
g/MJ	CO2 eq emissions for solar energy	9.7	15.5	posnorm
g/MJ	CO2 eq emissions for German electricity mix	111.38889	130	posnorm
month	average storage time in ca system	3	8	posnorm
month	average storage time in na system	1	1.5	posnorm
%	desired coefficient of variation in percent	0.05	0.15	tnorm_0_1
%	coefficient of variation in apple harvest	0.05	0.1	tnorm_0_1
t/ha	range of maximum yields	32	32	const

A Collaborative, Interdisciplinary, Undergraduate Course on Generative Art

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Abstract. We describe an undergraduate course on generative art, co-taught by a professor of Fine Arts and a professor of Mathematics, offered at Ohio Wesleyan University in Spring 2020. Starting with a definition of generative art as “art in which the artist deliberately cedes control over some significant aspect of their work to an external agent,” twelve undergraduate students worked to create generative art across a range of two-dimensional media, both digital and physical. Principles of design, color, and computation were emphasized throughout. In this paper we describe the overall aims of the course as well as some of its key assignments and outcomes.

1 Introduction

The meaning of the term “generative art” is somewhat contested. A reasonably broad definition would be *art in which the artist deliberately cedes control over some significant aspect of their work to an external agent*. This external agent can take the form of natural or mathematical processes, machine-driven randomness, other individuals (e.g., the audience), etc. (cf. Galanter 2008). This description encompasses a more typical, and more restrictive, definition of generative art as *art that is created using processes or systems that are autonomous or semi-autonomous*. These processes can be variously deterministic or random, digital or mechanical, human guided or fully automated. In general, autonomous systems are those which progress and evolve according to predefined rules, often generating tremendous complexity out of the iteration of many simple operations. These systems, and the manner in which they are interpreted/visualized, determine the form and composition of the piece without direct intervention by the artist.

A good discussion on the distinction between art that is (and is not) “generative” can be found in Galanter (2016) where he traces the origin of the genre to early computer/electronic music, advances in computer graphics and animation, and various youth cultural scenes (demoscene, VJ culture, etc.). Contemporary examples of generative art include, to name only a few: the combinatorial sculptures of Sol LeWitt; the computer-plotted drawings of Peter Beyls (Beyls 2014); the machine wall drawings of Tristan Perich; the wind-driven machine drawings of Cameron Robbins; Harvey Moon's drawings in which an automatic plotter traces the path of a caged cricket; Angela Bulloch's bench-activated drawing machines; Jason Salavon's composite averages of hundreds of thematically similar digital images.

A key feature of most generative art is its ability to straddle the line between complete symmetry/order and total asymmetry/disorder. This in-between space tends to exclude works of art determined fully by human intention as well as more chaotic pieces in which the organizing principle or underlying structure is unapparent. Aesthetically, we often see pure symmetry as sterile and uninteresting, while total asymmetry is often seen as just noise. According to McManus, "asymmetry probably results most effectively in beauty when the underlying symmetry upon which it is built is still apparent" (McManus 2005). This tendency for generative art to both be guided by human intention, but not to be bound by it, is a key topic we emphasize on our course.

Many of the artists we shared with our students over the course of the semester are/were not working in the realm of generative art per se. However, we explored parallel concerns in the relationships between order and disorder in their work – pattern and pattern disruption. When the particular art medium requires the artist to make a mark, weave a row, etc, how can the artist build in chance? In what ways can they improvise without the piece feeling contrived, like an illustration of chance and discord, rather than a true tension between repetition and anomaly?

When talking about improvisation in visual art people often draw parallels with jazz. In both music and art, establishing a basic understanding of how formal elements function allows for more freedom when improvising. For example, the works of both Anni Albers and the weavers of Gee's Bend find freedom within certain boundaries, dictated by incorporating known patterns and shape motifs, harmony and rhythm. With computer generated randomness (improvisation), harmony and gestalt also depend upon small patterns/motifs to appear within the seemingly random noise.

Having acknowledged that generative art can be (and often is!) produced using many different artistic media (e.g., sculpture, photography, textiles, etc.), nevertheless, it is certainly true that the bulk of generative artists today work with a computer and utilize algorithmic processes implemented in various programming languages (e.g., Processing). Hence, it is natural that an interest in generative art might lead to collaborations between artists and computer programmers. The authors of this paper represent one such collaboration. Jeff Nilan is an artist who works in photography, book arts, and textiles. Craig Jackson is a mathematician who works with computational models of complex systems such as the Earth's climate.

In this paper we describe one outcome of the authors' ongoing collaboration: an undergraduate course offered in Spring 2020 on generative art. The students who enrolled in the course largely came from two distinct backgrounds: first, traditional fine arts students who had a good exposure to principles of design, form, color, and composition; second, science students with a background in mathematics, data analytics, and/or computer programming. Each of these groups of students lacked one set of key skills to complete the weekly assignments on their own. Therefore one of the primary aims of the course was to fill in these missing gaps in order to utilize computation and algorithmic thinking, as well as a variety of photo and textile processes, to produce interesting generative art in both digital and physical form.

2 Selected Course Aims and Assignments

Our course is designed around approximately 12 individual, yet related assignments. Students submit their work in advance to be followed by a group critique. A third of the assignments are related to programming a computer to make "random drawings," the next third are related to random tilings, and the last third are a mix of more advanced topics that allow for a deeper exploration and which may serve as the basis for a substantial final project.

At the core of the course's visual concerns are principles of design and color interaction. In our initial assignments we were primarily focused on non-representational design and color compositions – imagery that does not represent or depict any identifiable person, place or thing. As such, our concerns were with formal elements and the resulting "content" of the work is its color relationships, shape variation, texture, size and scale. With design, our primary concern was that of creating illusionistic movement and illusionistic space – making something flat and static to appear dimensional and in flux. With color, our primary concern was that of color interaction – exploring how hues are always influenced by one another, are not static but relative and changeable.

In this section we describe the aims and outcomes of five different assignments. All of the programming necessary for each assignment was carried out using the Mathematica scientific programming software.

2.1 Constrained Random Drawings

The first several assignments in our course involve getting a computer to make a "random drawing." Of course, the precise meaning of the word "random" is unclear at first and requires a precise meaning if we are going to be able to get the computer to make any kind of drawing at all. A good starting place for this kind of exercise is to learn how to make a simple random walk. Further refinements can then be made in order to change the manner in which the random walk is performed and to constrain it to lie within a prescribed area.

A random walk is a recursive process that traces out a path by repeatedly deciding to move randomly in one of any number of preselected directions. For example, the following code will begin with a point at the origin and repeatedly move in one of four randomly chosen directions (right, left, up, down).

```
directions = {{1,0}, {-1,0}, {0,1}, {0,-1}};
pt = {0,0};
walklist = {pt};
For[j=1, j<=100, j++,
  pt = pt + RandomChoice[directions];
  AppendTo[walklist, pt]
]
```

The points that are visited in this process are recorded in the list `walklist` which can then be visualized by joining the points sequentially together with a drawn line (see Figure 1).

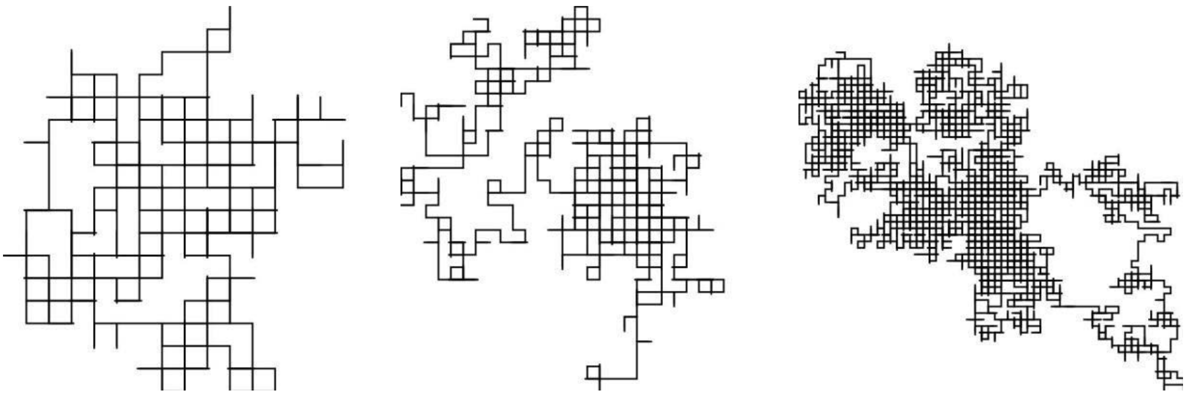

Fig. 1. Random walks. From left to right: 500, 1000, 5000 iterations.

This simple example allows for variations to the algorithm that produce different types of drawings. For example, we can allow a larger set of directions, even infinitely many, in which to move. We can select the direction in which to move at any given step in such a way as to prioritize some directions over others. Finally, we can insert conditionals (if/else statements) in order to prevent the random walk from crossing obstructions or moving outside a predetermined area. Altogether, though, the many possible variations on this simple random walk code leads to a vast array of possible "styles" for a computer-generated random drawing. Three examples, created by students, are shown in Figure 2.

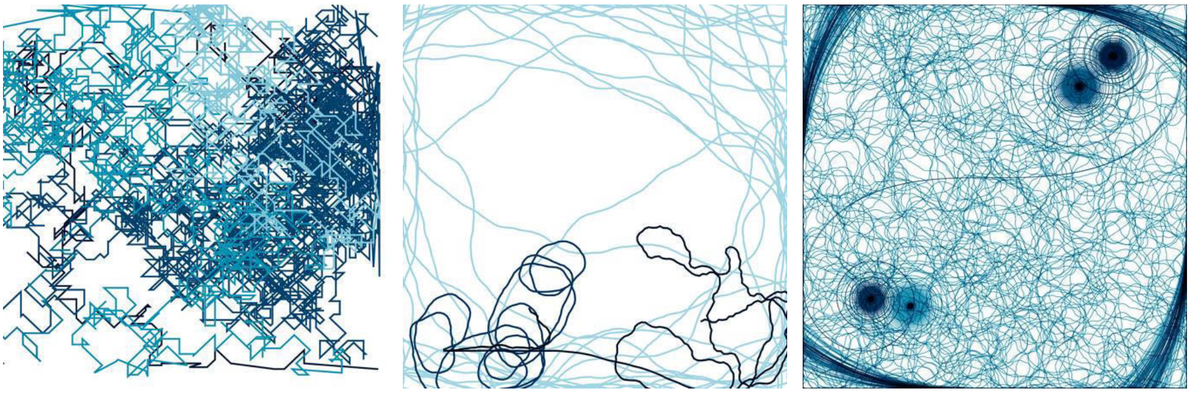

Fig. 2. Constrained random drawings. Work by Madeline Henson, Clay Sturts, and Max Goulakos (left to right).

From a design standpoint the first assignment introduces the problem of how to create illusionistic space and movement with a single line-weight thickness. When line thickness is undifferentiated throughout a drawing, spatial illusion can only happen with variation in the relative lightness and darkness of the lines. Incorporating value (relative lightness or darkness) of line creates illusionistic space and movement. Even with uniform line thickness, light lines tend to advance, darker lines tend to recede. Hence, students discover, in a very fundamental way, how to manipulate a 2D picture plane through value alone.

2.2 Filling Voids with Value

While the constrained random drawing assignment focuses on principles of design like line value, density and movement we use the subsequent assignment to focus on a different set of design and color principles simply by giving students the task of filling in the gaps in their existing constrained random drawing with shades of various values. Specifically, students are constrained to select values that are neither fully black nor fully white. The process of filling the voids was not automated, but was done manually in photo editing software (GIMP). The intention behind the assignment is to use contrasting values to add depth and complexity to a line drawing. In particular, students were advised to consider the phenomenon by which a darker value next to a lighter one can act to steal even more of the lighter region's value, enhancing color contrast and therefore illusionistic depth.

While the initial assignment allowed for illusionistic movement and depth in an otherwise static line drawing, Filling Voids with Value introduces the potential for scale to further manipulate our sense of space and movement. For example, small spaces (cavities) between line loops can be emphasized through value, therefore appearing closer and more prominent. The same line drawing can be filled with different densities (value levels) therefore altering our perception of how it functions spatially. Three examples of student work are shown in Figure 3. Note that the images shown in Figure 3 are the same as those shown in Figure 2, only the voids have been filled.

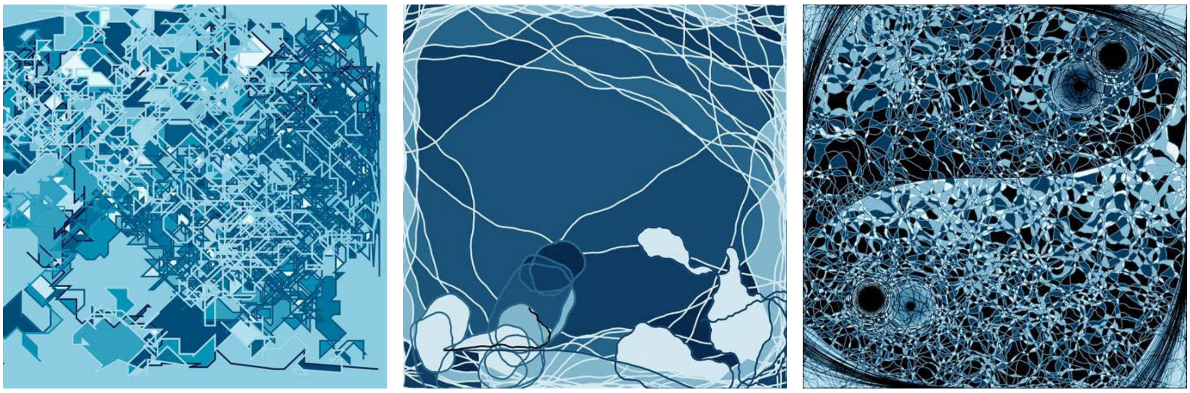

Fig. 3. Constrained random drawings in which voids have been filled with value. Work by Madeline Henson, Clay Sturts, and Max Goulakos (left to right).

This void filling assignment also introduces color in a limited but fundamental sense. We use shades (base hue + black) and tints (base hue + white) of a single color to create a value range. Avoiding absolute black and white keeps the students within the value range of a particular color – holding onto the "color identity" throughout the value spectrum. The monochromatic spectrum allows for both contrast and smooth progressions between values and avoids more complex combinations between hues, such as complementary contrast/vibration.

Technically speaking, this assignment is not difficult since we allow the students to manually fill their voids using the paint bucket tool in a digital image editor such as GIMP or Photoshop.

2.3 Triangular Tilings

"Tilings" are a regimented way to subdivide the two-dimensional plane into a discrete set of regular pieces (tiles) that fit together evenly. The tiles themselves can be of any shape. For our course we focused on simple shapes such as triangles and squares. In contrast to the previous assignment where "shapes" were created by intersecting lines and then filled with a value range of hues to create depth, the Tiling with Triangles assignment introduces shape as a fixed repeated motif. The initial shapes (in this case triangles) do not vary in size or value but only in arrangement within a square. As such, the design focus is initially on pattern (and pattern disruption), repetition of form, theme/variation and anomaly, rather than on illusionistic space.

Our work here was particularly inspired by the notebooks of Anni Albers (Albers 2017) in which Albers experimented with many variations of triangular tilings hand-drawn on gridded paper. Triangular tilings are also featured in many of Albers more formal pieces including her large tapestry "Camino Real" (1967). For this assignment, students need to write an algorithm that will produce a random triangular tiling (though the exact nature of the tiling is up to them) from a collection of colored tiles.

In order to accomplish this, students can pre-generate a set of tiles stored as graphics primitives and fill out an array/matrix of these tiles using random selection. The precise randomness of the selection can be influenced by its place in the array, by the tiles already chosen, by pure chance, and so forth. After the array of tiles has been selected, the entire piece is visualized. Two examples of student work are shown in Figure 4.

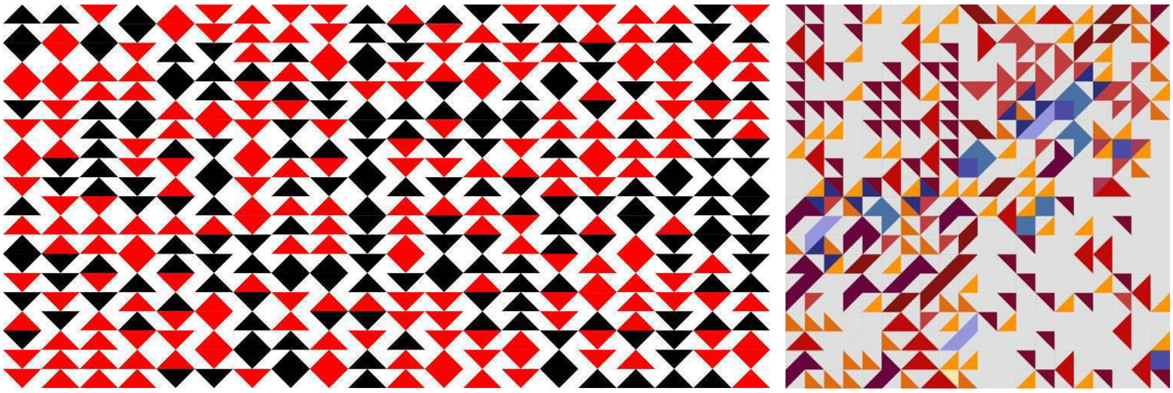

Fig. 4. Triangular tilings. Work by Madeline Henson and Isabelle Ammendola (left to right).

The entire process of creating a random triangular tiling requires list management techniques, nested loops, if/else statements, as well as the ability to produce a final composition by layering many different graphics primitives onto the same plot.

2.4 More Complex Tilings

The aim of our next assignment is to explore more aspects of color interactions by making tilings with more complex tiles and a constrained color palette. Specifically, an allowable palette must contain 1) two complementary colors; 2) one set of four colors that are analogous to one of the colors from (1); 3) one wildcard color (optional); and 4) at least four variations in shade and/or tint for each of the four complimentary colors. This seemingly simple palette allows for complex color effects including color contrast, optical blending and rhythmic progressions.

Inspiration for this assignment came largely from aerial landscape photographs of rural America in which the patterns created by subdivision of agricultural parcels and use of central pivot irrigation create a patchwork of circles and rectangles of various analogous shades and values.

Most of the technical aspects of this assignment are similar to the previous assignment on triangular tilings. However, here more complex tiles need to be stored as potentially long lists of graphics primitives, which themselves need to be selected according to some randomized algorithm.

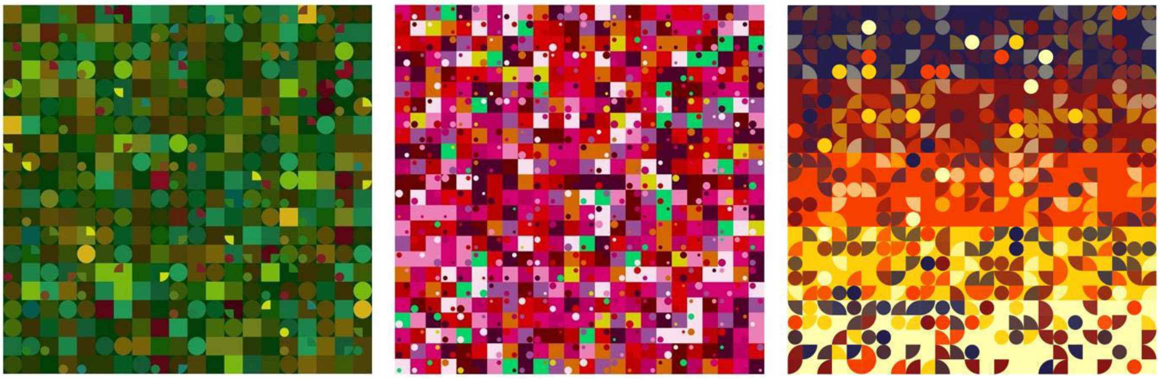

Fig. 5. Tilings with semi-complex tiles with color considerations. Work by Madeline Henson, Rand Barton, and Max Goulakos (left to right).

2.5 Image Averaging

The last assignment we describe here is possibly the simplest in a technical sense. For this assignment students need to select a single object and photograph it from many different angles (or take a large number of photographs of different objects that fit a common theme) and make a single composite image by averaging.

To accomplish this students need to convert their digital images into a matrix of pixel values (e.g., grey levels or RGB values) and then simply compute a pixel-by-pixel numerical average. These numerical averages were the taken as the pixel values of the final, averaged image.

This assignment was inspired by the work of Jason Salavon, especially, but also much of the work in the cubist tradition. The idea is that even though the final composition is the direct result of deliberate choices made by the artist, the exact nature of the final image cannot be appreciated in advance. Ideally, the final composition should transcend being a mere assemblage of distinct subimages and invoke a sense of gestalt. That is, the final image should be something other than a sum of its parts. The irony here is that, in a technical sense, the final image is *nothing other* than a sum of its parts, since the final image is directly composed as an average.

This assignment allows for elements of the previous four assignments to be incorporated into objective subject matter through the use of photography. As such, the images become “abstractions” or alternate ways of looking at recognizable subject matter. Students attempt to make pictures of subject matter that already includes qualities of line, shape, motif, anomaly, illusionistic space and movement. In this case, image averaging may actually serve to reduce the clarity or alter the original connotation of the subject matter.

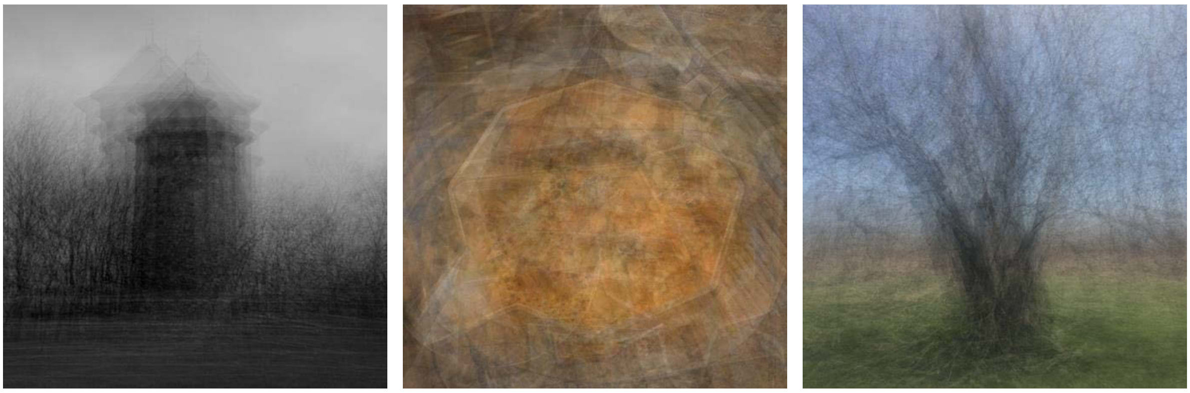

Fig. 6. Composite averaged images. Work by Rand Barton, Alexis Yracheta, and Max Goulakos (left to right).

3 Discussion

Courses on generative art, similar to that which we have sketched out above, can fit well within an undergraduate curriculum that values interdisciplinarity and cross-disciplinary collaboration. The course can be appealing to a wide variety of students including those that are firmly grounded in the arts as well as students from STEM majors. In fact, when we offered the course in Spring 2020 it was cross-listed as both an art course and a math course. Depending on which version a student signed up for, the course would meet either an arts or a math distribution requirement.

In future iterations of the course, we will seek to focus more on ways to take what students do in the computer and bring it into physical form using various artistic media. We had such plans in 2020 and we were able to have students employ several photographic processes (cyanotype and standard darkroom printing) to turn their digital work into physical artifacts. However, the covid pandemic that began in March 2020 resulted in our institution moving to remote education. Because of this, for the remainder of the course, we mostly focused on digital work that could be displayed on a screen.

We see some interesting potential to incorporate weaving and other textile/fiber arts into the next iteration of the course. Weaving, in particular, holds particular promise due to its combinatorial nature and the fact that weaving plans are often generated algorithmically.

References

Albers, Anni (2017): Notebook 1970-1980. Ed. Brenda Danilowitz. Zwimmer Books.

Beyls, Peter (2014): Simple Thoughts. AsaMER.

Galanter, Philip (2008): What is Complexism? Generative Art and the Cultures of Science and the Humanities. Proceedings of the International Conference on Generative Art, Milan, Italy.

Galanter, Philip (2016): Generative Art Theory. In Companion to Digital Art, Ed. Christiane Paul. Wiley-Blackwell.

McManus, I. C. (2005): Symmetry and asymmetry in aesthetics and the arts. European Review, Vol. 13, No. 2, 157–180.

Is the Industrial Turn in Renewables Killing Denmark's Energy Cooperatives?

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Abstract. This study contributes to sustainability transitions research by taking an energy democracy perspective on important, comparative aspects of community energy development. Locally rooted wind energy cooperatives have played an important role in Denmark's clean energy transition but recently 4 out of 5 such projects have shut down. This development has been associated with a turn to large investor-driven industrial-scale renewable energy projects. The broader participation of cooperatives in other parts of Denmark's energy sector has received little scholarly attention. The purpose of this study is to provide a synthesis across different technologies and types of cooperatives showing the industrial turn's impact on the cooperative energy landscape. This paper builds on the identification of almost 800 energy cooperatives. Cooperatives remain a substantial part of the energy system in Denmark. They account for 26 percent of total turnover in the energy sector and are especially important in electrical distribution, district heating, biogas, and onshore wind power. Combining descriptive statistics and interviews with key actors in the field, this paper shows how the industrial turn negatively affects producer-owned wind and solar power cooperatives, and farmer-owned biogas cooperatives. Other types of energy cooperatives like district heating companies seem unaffected. A novel phenomenon is identified: The rise of energy mega cooperatives in the field of electrical distribution. These cooperatives have 100,000s of members and function as business groups with diverse activities in renewable energy generation and distribution. The study highlights a large potential for participation of retail- and housing cooperatives in renewable energy supply and suggests that comparative perspectives are needed to better understand the potential for democratizing Europe's clean energy transition.

Key words: sustainability transitions, energy democracy, community energy, energy cooperatives, grassroots innovation.

1 Introduction

There is global consensus on the need to act on climate change by decarbonizing energy systems. Sustainable energy transitions are rapidly evolving in many countries and they are not only technical processes, but have major impacts on ecology, economy, politics, and governance (Solomon & Krishna, 2011; Markard, 2018). The transition to clean energy sources, like all sustainability transitions, is closely linked to social change and the potential for more emancipating energy futures (Gatto, 2022). The climate emergency has also increased societal interest in energy. Popular mobilizations such as “Fridays for Future” have influenced political agendas in some countries. Recent shocks such as the 2021-2022 energy crisis, and the Russian invasion of Ukraine, have had dramatic effects on European energy policy and increased the focus on carbon neutrality and energy security goals.

Sustainability transitions can be defined as “large-scale disruptive changes in societal systems that are deemed necessary to address grand challenges, such as climate change” (Krupnik et al., 2022, p.2). Recent social science approaches to energy research include themes such as the phase-out of existing technologies like coal and nuclear; influence of legal and technical contexts, or social norms, on the development of renewable energy; and ownership and socio-spatial conflicts over renewables. In this context, energy cooperatives have been identified as alternative niche actors with potential to contribute to a transformation of the existing fossil-dominated energy system in Europe. This is often linked to the emergence of decentralized, community-based local solutions to energy production and distribution (von Wirth et al., 2020). Germany and Denmark have been highlighted as places where democratic, bottom-up energy initiatives have been particularly successful. However, cooperatives and associated social movements now appear to be at a crossroads as large-scale commercial renewable industries are consolidating their positions (Mey & Diesendorf, 2018; Rommel et al., 2018). The structural change in governance, legal, technological, and other conditions to the advantage of commercial energy industries is a trend observed across Europe (Kirch Kirkegaard et al., 2021; Markard, 2018; Novikau, 2022), and can be described as an “industrial turn”.

Too little is known about the present role of cooperatives across technologies in Europe’s energy sector and the Danish case might well serve to shed light on emerging trends and potentials in the context of the industrial turn. The results presented in this paper is based on descriptive analysis of quantitative data and interviews with 10 energy activists, industry association representatives, and researchers from the fields of community energy and cooperatives (Kohl, 2022).

1.1 Research question

The research question is:

How does the industrial turn in renewables affects Denmark’s cooperative energy landscape?

The paper is structured as follows: In section 2, the background and context of energy cooperatives is described. In section 3, the theory is reviewed with a focus on conceptualizations of energy democracy, and the research methods are described. Section 4 gives an outline of the broad participation of cooperatives in Denmark's energy sector. In section 5, findings on the impact of the industrial turn on the cooperative energy landscape is presented and discussed, followed by conclusions in section 6.

2 Why cooperatives? Background and context

Energy cooperatives are part of a wider, emerging phenomenon across Europe of different kinds of local, citizen-based, and democratic energy initiatives, sometimes grouped together as "community energy" (Caramizaru & Uihlein, 2020; Ruggiero et al., 2021; Seyfang & Haxeltine, 2012). The REScoop federation of European renewable energy cooperatives lists 1,200 cooperatives as members (REScoop, 2022). In Denmark (population 5.9 million), there are hundreds of cooperatives with production or distribution of energy as a primary activity. The claims to fame of Danish energy cooperatives are as innovators and pioneers of wind power, and as generators of local participation and local economic development. This development began after the 1973 Oil Crisis where a shift in Danish energy policy encouraged local, innovative solutions to energy supply. This led to the rise during the 1980s and 1990s of community-based wind power "guilds", or cooperatives. Wind cooperatives initially benefitted from investment subsidies and a fixed price for each kilowatt-hour (kWh) produced (feed-in-tariff, or FIT) (Hvelplund, 2013). From the early 2000s, support schemes were gradually removed by governments who favored neoliberal, market-based policies. This led to a dramatic decline in community-based wind power (Kirch Kirkegaard et al., 2021). When the proliferation of wind turbines peaked in 2000 with more than 6,200 installations this was very much the result of local and community engagement in wind power. Even in 2008, when large commercial actors had well begun a takeover of the market, and the number of wind turbines had dropped to 5,200, around two thousand turbines were still owned by community-based cooperatives (Energistyrelsen, 2008).

Wind guilds are the best known and most studied example of renewable energy cooperatives in Denmark, but they are by far not the only cooperative component of the energy sector. Cooperatives can be defined as autonomous, jointly owned enterprises guided by a set of values (see ICA, 2022), and governed by a "one member, one vote" principle. Apart from this shared democratic principle, Danish energy cooperatives have diverse business models, they engage with different energy technologies, and are made up of groups of people with different profiles. First of all, cooperatives do different things in different ways. At one end of a fossil-renewables spectrum is a cooperative such as consumer-owned energy company OK that runs a network of 670 low-price gasoline stations and has around 11,500 members. At the other end of the spectrum is the emblematic 8,000-member strong producer-owned offshore wind guild Middelgrunden, founded by environmental activists. The bulk of energy cooperatives, in particular district heating companies and electric grid companies, are neither all fossil, nor all clean energy, but are in a process of transition, with short- or mid-term decarbonization goals (Kohl, 2022).

Also importantly, there tend to be shared characteristics between the members within certain types of energy cooperatives, but not necessarily between different types of cooperatives. Thus, cooperative members are not necessarily "activists". Biowaste and biogas cooperatives are for example often founded by local farmers as producer-owned enterprises. Consumer-owned district heating, and electrical grid cooperatives, are, for legal reasons, open to all households in certain areas, resulting in more diverse membership. More activist-driven types of membership are seen in association-style cooperatives (often linked to local community development schemes), or multi-stakeholder cooperatives like eco-villages. Other membership profiles can be found in cooperatives that engage in energy production as a secondary activity, like retail or housing cooperatives. The diversity of Denmark's energy cooperatives is also reflected in the fact that they do not have a common umbrella association (like the DGRV in Germany) but tend to form part of business associations with non-cooperative firms working in their specific business area.

3 Theoretical and methodological framework

It is widely observed that the large-scale rollout of renewables that increasingly contributes to energy supply across Europe comes with a structural change in the institutional context of renewable energy projects. This includes a change in policies from support schemes like feed-in-tariffs, which benefit community-based projects, to market-based set-ups (Krupnik et al., 2022). This "industrial turn in renewables" occurs at different times in different places and can have dramatic effects on ownership modes. Kirch Kirkegaard et al. (2021) show how the original, local cooperative ownership of much of Denmark's onshore wind power shifted to distant and international corporate ownership, and link this to changes in four other entangled dimensions. First, a shift in policies and incentives like abandoning feed-in-tariffs and requirements of local ownership. Second, a change in turbine technology from small and mechanically simple turbines up to 500 kilowatts to large and complex ones of up to 8 megawatts. Third, a substantial increase in the size of the investment required. Fourth, a change in financing from low-risk, cheap mortgage loans to high-risk complex financing instruments. This is also essentially also a transition from environmentalist ideology to profit and capitalism.

Markard (2018) identifies this second phase of the energy transition as a challenge to existing technologies, organizations, and infrastructures. A decline of established business models comes along with intensified political and economic struggles of actors like utility companies, industry associations, and grassroots. This increasingly puts social movements for decentralized control of energy systems under pressure (Mey & Diesendorf, 2018; Rommel et al., 2018). Such movements and environmentalists have coined and use the term “energy democracy” to describe their struggles against top-down approaches to decarbonization and the current centralized fossil-based energy system. In this context, energy democracy entails social ownership of energy infrastructure, public participation in decision-making, and a focus on environmental and social justice (see for example Climate Justice Alliance, 2022).

“Energy democracy” is also used as a theoretical concept by social science researchers to describe aspects of democratizing the energy system including fostering collective participation, transparency, grassroots innovation, and democratic forms of ownership and decision-making, usually related to renewables (see Wahlund & Palm, 2022; Szulecki & Overland, 2022). There is a growing critical and feminist inquiry of the actual functioning of grassroots and cooperative energy initiatives in regards to participation, gender, economic privilege, etc. (see Allen et al., 2019; Lazoroska et al., 2021). Paul (2018) suggests that “Energy democracy can be understood as an expression of a new spatial politics of energy transition, evident in the protests, civil disobedience, and alternative energy practices of civil society*”.* This paper focuses on “alternative energy practices” in Denmark, in a study aiming to better understand the impact of the industrial turn on cooperatives across a spectre of different technologies, by looking comparatively at a wider cooperative energy landscape.

Previous research has often focused on case studies of cooperatives, or a single technology, such as wind turbines, district heating or biogas. A methodological challenge in a comparative synthesis study like this one is that there is no central, official data on energy cooperatives in Denmark. The Danish Ministry of Energy does register – through the Danish Energy Agency – all renewable energy installations (see Energistyrelsen, 2021). However, this registration does not necessarily reveal the true form of ownership of the particular installation, as shown in detail by Gorroño-Albizu (2021) in the case of onshore wind farms. In general, ownership forms include private individuals e.g. farmers, and land- or home-owners, municipal, state company, cooperative, private investor-led companies, or a mix of these.

One main empirical source of this study is data gathered from desk research (descriptive statistics) on Danish Ministry of Energy publications. Another main empirical source of data comes from mappings done by the Danish Research Institute for Democratic Businesses (Demokratisk Erhverv) of 20,336 Danish cooperatives (DE 2022a, see also Jørgensen et al, 2019). The mapping compares accounting data from Statistics Denmark with data from Denmark’s Central Business Register to identify most cooperatives in all business sectors, including energy supply. The information from these two main data sources was summarized and collated to provide an overview of the general role of cooperatives in the energy sector.

However, this data alone often did not show exactly the participation of cooperatives in specific energy sectors, nor did it explain decreasing or increasing roles of cooperatives. Therefore, to provide a descriptive analysis of the quantitative data set, additional data was also gathered via semi-structured qualitative interviews, combined with conversations, and correspondences, with 10 informants. Six were community energy activists and/or cooperativists working with respectively RESCoop Europe (European federation of citizen energy cooperatives), INFORSE (International Network for Sustainable Energy – Europe), BL Danmarks Almene Boliger (Danish Federation of Non-Profit Housing Providers), an eco-village, a wind guild and a biogas coop. Two represented industry organizations: Dansk Fjernvarme (Danish District Heating Association), and Biogas Danmark (Danish association of biogas stakeholders), and two were academic researchers on community energy and cooperatives.

Interviewees were selected to reflect both activist and professional perspectives on energy cooperative experiences, as well as different technologies and a diversity in organizational forms: district heating companies, wind guilds, solar cooperatives, grid companies, housing cooperatives and eco-villages. Interviews were conducted between January and May 2022. Data from interviews, together with some media sources, served to qualify the quantitative data gathered via desk research. This also allowed for the inclusion of concrete examples of cooperative initiatives in different parts of the energy supply spectre. Some of the initial results were previously used in a report on energy cooperatives for the Danish Business Authority (Kohl, 2022).

4 An introduction to the role of cooperatives in the energy sector

Cooperative ownership in the Danish energy sector hit the public and political agenda in 2018 around a controversy over the proposed sell-off of state-owned electric grid company Radius. Critics argued that Radius, which distributes power to households in the capital city Copenhagen, should be considered "critical infrastructure" and therefore not be sold to a private, commercial investor. After considerable public pressure, a parliament majority decided that Radius should instead be sold to regional consumer-owned grid cooperative, SEAS-NVE (Elkjær, 2019). In this way, consumer-owned utility cooperatives solidified their long-standing tradition of occupying key positions in critical energy infrastructure, although within a general context of neoliberal market reforms and privatizations in the Danish energy sector.

Social science studies have highlighted Denmark as a frontrunner in renewable energy transition with a high degree of local and public participation and ownership, often focusing on wind power guilds and district heating cooperatives (Gorroño-Albizu, 2021; Kooij et al., 2018; Mendonca et al., 2009). Decentralized, bottom-up initiatives are common also in other countries, but the Danish case is particular in that energy cooperatives like wind guilds emerged already in the 1970s linked to alternative social movements and anti-nuclear activism. In the case of grid cooperatives, some trace their roots back to the introduction of public electricity in the 1890s where municipal companies dominated urban supply, and cooperatives dominated rural supply (Frederiksen, 2018).

Today, decentralized energy generation is spreading fast, and the Danish Energy Agency lists more than 100,000 small or larger electricity producing plants (Energistyrelsen, 2021). However, official energy statistics do not provide detailed descriptions of ownership constellations which makes it difficult to obtain precise and up-to-date data of the total scope of energy cooperatives (see also Gorroño-Albizu et al. 2019). The most recent survey from the Danish Research Institute for Democratic Businesses (2022a) estimates that “democratic enterprises” (see definition below) account for 26 percent of total turnover in the Danish energy sector. The relatively large contribution of cooperatives is mainly due to the activities of a handful of very large consumer-owned grid company business groups.

The following description sheds light on central fields and actors in the cooperative energy landscape, without pretending to provide an exhaustive picture. The main points are that cooperatives play key roles in distributing electricity to households and businesses, in producing and distributing heat, in generating onshore wind power, and in production of bioenergy, especially biogas. Many cooperatives also play roles in renewable energy supply as a secondary activity, for example housing cooperatives or retail cooperatives installing solar roof farms. Such energy generation projects are often developed together with the installation of other technologies that can potentially use electricity from renewable sources like heat pumps or charging stations for electric vehicles.

4.1 Definitions: Cooperative or democratic enterprise?

Energy cooperatives in Denmark seldom use the word *kooperativ* (cooperative) in their company name. That term seems to be associated with employee-owned cooperatives outside the energy sector. The classic legal organizational form of energy cooperatives is as an *amba* or *andelsselskab med begrænset ansvar* (limited liability cooperative), but a variety of other cooperative ownership models exists. In the following, cooperatives will be defined according to the Danish Research Institute for Democratic Businesses’ definition of a “democratic enterprise”. That is an independent business organization governed by a democratic assembly on the principle of one member, one vote - or at least 50 percent controlled and/or owned by such a democratic assembly – and with a relatively open membership (DE, 2022b). For a detailed discussion of the overlapping concepts of cooperatives and democratic enterprises see Hulgård et al. (2022).

4.2 The cooperative energy landscape

A 2019 mapping of all cooperatives in Denmark lists a total of 785 cooperatives in the energy sector (Jørgensen et al., 2019). The survey is based on data drawn from the Central Business Register and excludes very small, or unconventional, cooperatives. 737 cooperatives are listed in the category of "consumer-owned democratic companies" and are divided according to their business branch subcategory: Heat supply (328), production of electricity (312), electricity trade (43), distribution of electricity (31), construction of cable networks for electricity and communications (23). 48 cooperatives are listed in the category of "association-owned democratic companies", all in the subcategory of production of electricity. No energy-related cooperatives were listed in the category of "employee-owned companies". Three energy-related cooperatives were listed among the largest of the "consumer-owned democratic companies" defined by having more than 500 employees. All these three cooperatives would seem to play a marginal role to the discussion of clean energy transitions and the industrial turn in renewables. The first is the gasoline retail cooperative OK; the second is the energy and water metering company Kamstrup, owned by OK; and the third is electrical technology firm EL:CON, owned by grid mega cooperative NRGi.

In the following a grounded description is provided of the participation of cooperatives in different energy technologies and fields: 4.2.1 electric power distribution; 4.2.2 district heating; 4.2.3 bioenergy; 4.2.4 wind energy; 4.2.5 sun energy; 4.2.6 water energy; 4.2.7 geothermal energy; 4.2.8 eco-villages and energy communities; 4.2.9 energy research and development.

4.2.1 Electric power distribution

Electricity is traditionally delivered from producers to consumers through an electric grid, consisting of transmission lines (the highways of power), substations, and the distribution lines that connect with end-users in households and businesses. This traditional model of delivery is increasingly challenged by the expansion of decentralized renewable energy generation where some consumers are at the same time producers. In Denmark, the state-owned enterprise Energinet acts as transmission system operator (TSO) and owns the transmission network for electricity (and natural gas). Regional and local grid companies, also known as distribution system operators (DSO), own and operate the distribution network that leads power into people's homes.

Most of Denmark's around 40 grid companies are consumer-owned cooperatives (Energistyrelsen, n.d.). Among the largest are mega cooperatives like Andel (formerly SEAS-NVE), NRGi, Norlys, and Energi Fyn, who all have several hundred thousand members. Andel alone distributes around 40 percent of all electricity in Denmark and is owned by 400,000 households, corresponding to 1 in 7 of the country's 2,8 million households. The major consumer-owned grid companies are in practice energy business groups with diverse activities including generation of renewable energy, natural gas supply, IT- and telecommunication networks, etc. Energy Fyn is an example of a regional grid mega cooperative with 200,000 members from the island of Funen that owns and operates 26 wind turbines, manages street lightning, develops fiber-optic cable networks, and distributes natural gas, besides the core activity of electric power distribution.

4.2.2 District heating

District heating is the dominant technology in heat supply and 64 percent of all households are connected to district heating networks. Networks are expanding steadily with around 20,000 new households connected every year since 2014 (Dansk Fjernvarme, 2020). As of December 2019, there are 323 cooperative district heating companies who together accounted for 34 percent of all district heating sold in Denmark (Forsyningstilsynet, 2020). There are also around 50 municipal companies and a few private firms. District heating is a transmission system that can be connected to any source of heat. District heating today is generated from renewable sources like biomass, biogas, wind, solar, and geothermal, as well as industry surplus heat, and fossil-based fuels like natural gas, coal, waste, and oil. District heating plants increasingly install technologies like heat pumps and electric boilers that can make use of electricity from renewable sources. The national district heating business association estimates that 52 percent of the heat supply is based on renewable sources (Dansk Fjernvarme, 2020).

District heating cooperatives outside large cities sometimes rely heavily on biomass such as straw from local agriculture. Solar heat plays an increasing role and at least 120 district heating companies have invested in solar installations. One example is the consumer-owned cooperative Dronninglund Fjernvarme that supplies heat to around 1,500 households. In 2021, 70 percent of local heat supply came from solar-powered heat pumps connected with a large interseasonal heat storage. The remaining 30 percent came from natural gas (Ingvardsen, 2022). Another widely used technology is biogas. In some cooperatives, the farmers who supply manure to the biogas production are represented on the board alongside district heat consumers. The village-based cooperative Energi Vegger features another organizational design where the 150 household members elect four representatives to the board, the municipal council appoints one representative, and farmers who supply manure can elect a board representative without voting rights. The Vegger energy cooperative is part of a wider rural cooperative ecosystem that includes a grocery store, a culture house, and sports facilities (Hulgård et al., 2022).

4.2.3 Bioenergy

As already mentioned, bioenergy in the form of biomass like straw, or wood chips and pellets, biogas, and to a smaller extent also biofuels, are used by district heating cooperatives. Biogas is also a rapidly growing component of gas supply to some 400,000 households and companies connected to the gas distribution network. In 2020, an estimated 60 percent of total biogas production came from 35 farmer-owned cooperatives. The rest came mainly from individual, farmer-owned plants, together with industrial plants (Personal communication with Biogas Danmark). According to the Danish Ministry of Climate, Energy and Utilities, the share of biogas in the gas network is expected to increase from 20 percent in 2021, to 70 percent in 2030, and to reach 100 percent in 2040 (KEFM, 2021). Biogas is also thought to have potential to contribute to decarbonization of the transport sector and in connection with emerging power-to-X conversion technologies.

4.2.4 Wind energy

Wind power accounts for half of Denmark's electricity consumption, and figures are rising. The development of offshore wind parks and offshore energy islands dominates the political and media agenda. Cooperatives in general play a marginal role in offshore wind development. Among exceptions are the Middelgrunden wind energy cooperative operating ten 20-year-old wind turbines near Copenhagen's coastline, and mega cooperative Andel's 90-turbine wind farm at Rødsand II with an installed capacity of 215 MW. Onshore wind turbines still account for most of total wind energy production: 10 TWh out of a total of 16TWh (WindDenmark, 2022), and has the advantage of being considerably more cost-effective than offshore turbines (Energistyrelsen, 2022). Gorroño-Albizu (2021) found that 68 percent of installed onshore wind energy capacity was "citizen-owned" in 2016, and out of this share between 11 percent and 38 percent was collectively owned, usually in the form of "wind guilds".

Not all guilds fulfil the criteria of democratic governance as defined by the Danish Research Institute for Democratic Businesses. An example of a guild that is not a cooperative is Prøvestenens Vindmøllelaug. This wind guild with 500 members was created because commercial wind power developers were formerly legally obliged to offer a minimum of 20 percent ownership in the project to residents within a distance of 4.5 km. According to this wind guild's statutes, members vote according to their number of shares. The European federation of citizen energy cooperatives, REScoop, estimates that most Danish wind guilds do function according to cooperative norms (personal communication with REScoop board member Erik Christiansen).

4.2.5 Solar energy

Solar energy is generally generated in two forms. One is as solar heat (solar thermal collectors) which is of increasing importance in the district heating sector, as earlier described. The other form is solar power generation via photovoltaics (PV). Today, solar power covers only 4 percent of total electricity consumption, but the potential is far higher. Only few solar power cooperatives have been founded, mainly due to legal restrictions that complicate collectively owned projects. In 2005, environmental activists founded the Copenhagen Photovoltaic Guild which is operating two rooftop plants on buildings owned by the City of Copenhagen (Københavns Solcellelaug, 2022). Cooperative retail giant Coop amba, which was founded in 1896 and currently operates around 1,200 supermarkets, is increasingly installing industrial-size solar rooftop-farms, including the hitherto largest plant in Denmark (Energy Supply, 2020). There is also an increasing number of rooftop PV projects in the cooperative housing sector. Most of these projects are limited to providing lighting to common areas like stair halls and outdoor areas, but do not provide electricity to individual homes because of legal restrictions.

4.2.6 Water energy

Hydropower plays a marginal role in Denmark today but was previously very important. Cooperatives own most remaining historic hydropower stations. The largest is Gudenaacentralen, which covered a fourth of electricity demand in Denmark's largest province Jylland when it was inaugurated in 1921. Production is now around 14 gigawatt hours (GWh) (Gudenaacentralen, 2022). An emerging form of water energy is wave energy which is thought to have a potential role in future energy supply. One of the most important test centers facilitating innovation and research is run by Nordic Folkecenter for Renewable Energy, an education and resource center, founded as a cooperative by activists in 1983 (Bølgekraftforeningen, 2022).

4.2.7 Geothermal energy

Low-temperature geothermal energy is widely exploited by district heating cooperatives and housing cooperatives using heat pumps. High-temperature geothermal energy is still at an early stage in Denmark. Test facilities have shown that it is necessary to drill very deep to exploit high temperatures. In 2022, energy mega cooperative NRGi announced the take-over of a 20 percent ownership share in geothermal development firm Innargi. NRGi is based in the second-largest Danish city of Aarhus, and Innargi will develop a new project aiming to bring geothermal heat from a depth of 2 to 3 kilometers under the city. According to the plan, one-fifth of the district heating in Aarhus will sourced from high-temperature geothermal heat in less than a decade (Tornbjerg, 2022).

4.2.8 Eco-villages and urban energy communities

There is growing interest in eco-villages and their holistic approach to sustainability lifestyles. More than 20 Danish eco-villages are part of the national umbrella organization LØS, and many of them have developed integrated energy solutions, combining wind turbines, solar plants, heat pumps and other renewable technologies (LØS, 2022). Eco-villages are sometimes organized wholly or partly as cooperatives.

Examples include the cooperative village Karise Permatopia with 210 inhabitants. The village operates an 8.5 km long district heating pipe system based on a geothermal heat pump powered by a wind turbine. Local energy supply includes a charging station for electric vehicles. Currently, the village sells surplus electricity from own generation to the grid and at other times buys electricity. The vision is to become self-sufficient. Urban citizen energy communities are a novel phenomenon sparked by the adaption of EU's "Clean Energy Package" (EC, 2019) that gives citizens the right to generate, share, store and sell electricity. In this strategy, citizen energy communities are a key concept (Palm, 2021). A citizen energy community was founded in 2020 in Hvidovre municipality as a multistakeholder cooperative with participation of citizens, local businesses, and public institutions, together with the local district heating cooperative (EBO Consult, 2020). The purpose of this cooperative is to inspire and contribute to the clean energy transition in an urban area with some 6,000 inhabitants.

4.2.9 Energy research and development

Many cooperatives participate in innovation, research and development directly related to the above-mentioned fields and technologies. Also, gasoline retail cooperative OK is developing biofuels based on animal fat. An important actor in renewable technologies innovation is the grassroots-founded institution Nordic Folkecenter for Renewable Energy which is organized as an association-style cooperative with a democratically elected board majority (Nordisk Folkecenter, 2022). An example of an important employee-owned cooperative in the renewable energy landscape is the consultancy PlanEnergi. This cooperative has around 50 associated employees and has since 1983 advised developers of numerous renewable energy projects.

5 What are the effects of the industrial turn on energy cooperatives?

The industrial turn in renewables is often celebrated by Danish politicians who associate it with the massive investments in renewables by Danish state-owned energy giant Orsted (originally an oil and gas company) or with the export successes of Danish wind turbine manufacturers like Vestas. The fact that renewables are now contributing significantly to energy supply also influences a public discourse along the lines of "small was beautiful, but bigger is better". Community-based, idealist driven projects are increasingly seen as a thing of the past. The rise of industrial-scale renewable projects comes hand in hand with a crisis for especially wind, biogas, and solar cooperatives.

5.1 The rise and fall of wind energy cooperatives

The effects of the industrial turn on wind energy cooperatives are well documented. Wierling et al. (2018) found a stark decline in Danish wind cooperatives from around

1,000 to less than 200 in just ten years, a trend also observed by others (Bauwens et al., 2016; Gorroño-Albizu et al., 2019). This coincides with the dismantling since the early 2000s of incentives and support schemes that benefited community-based wind power development and is also influenced by the EU-mandated liberalization reform of the electricity sector (Kirch Kirkegaard et al., 2021). In 2018, a majority in parliament furthermore introduced a cap on the total number of onshore wind turbines, aiming to reduce the number of turbines from 4,200 to 1,850 by 2030 (Altinget, 2020). Consequently, many existing community-based wind guilds are left with few chances of developing new projects or renewing their aging turbines. Some studies indicate that rising local resistance against wind turbines might be explained partly by a loss of local community control and ownership over projects (Gorroño-Albizu, 2021; Kirch Kirkegaard et al., 2021). The wind farm at Hvide Sande harbor on the North Sea coast illustrates this dynamic, and also shows that there is still room for some innovative wind power cooperatives. Initially, local resistance stopped a private, commercial wind energy project here. Then in 2010, the local tourist association created a cooperative fund to finance developments in tourism and harbor infrastructure by profits from wind power. The fund retained 80 percent of ownership, and a local guild with 400 members took a 20 percent share. This version of the wind farm project did not generate strong protests. (Folketinget, 2012). Today, the local district heating cooperative has taken over the ownership of the wind farm.

5.2 A crisis in solar power and biogas cooperatives

The rise and fall of wind energy cooperatives contrasts with the lack of development of a significant cooperative movement around solar power. Solar energy cooperatives are common across Europe and a recent study from Germany shows that 80 percent of 835 energy cooperatives run photovoltaic solar installations (DGRV, 2021). In Denmark, a restrictive legal framework has prevented the emergence of more than a few experimental solar power cooperatives (see 4.2.5). Cooperative actors such as the social housing cooperative association BL, and REScoop, have identified as main obstacles the lack of the right to develop or operate internal grids across cadastral boundaries to create internal networks for production and consumption, and the lack of fair pricing (IDA Teknologivurdering, 2022).

The existing legal framework benefits the development of large-scale commercial solar photovoltaic projects but restricts the large-scale participation of housing cooperatives, eco-villages, and citizen energy communities. The (non)participation of the cooperative social housing sector seems particularly critical because of the potential of large-scale urban rooftop plants. BL is an umbrella association for 500 non-profit social housing cooperatives with around 1 million residents, and the association estimates that their estates could provide five to six percent of Denmark’s total household electricity consumption from rooftop plants alone if legal restrictions were lifted (IDA

Teknologivurdering, 2022). Furthermore, there is a dimension of conflict between, on the one hand, the cooperative housing sector's call for control of their internal electric distribution networks between residential units, and on the other, the electrical grid cooperatives defending their regional monopoly as distribution network operators and owners of the grid that connects every household.

Biogas cooperatives face similar challenges to wind cooperatives. Incentives and support schemes are being removed, and large commercial investors with industrial-scale projects have in recent years increasingly dominated the field (Booker Nielsen, 2022) In these new biogas plants, it is often only the manure supply that remains organized as a farmers-owned cooperative, while ownership and operation of the energy production itself, often in the form of upgraded biogas, is in corporate hands (personal communication with Biogas Danmark).

5.3 A steady expansion of district heating

Data calculated by the author shows that the share of heat supply coming from district heating cooperatives fell slightly from 36 percent in 2016, to 34 percent in 2019. Nevertheless, cooperatives are actually increasing their district heating networks and total production, as well as innovating and diversifying their intake of renewable energy sources. Only the municipal companies, that dominate many large urban areas, are also expanding, and at a higher speed given high population density in their areas of operation. The overall number of district heating cooperatives has decreased slightly because of mergers between small rural cooperatives. In this sense it does not seem that the cooperative model for district heating is in crisis.

5.4 A remarkable rise of mega grid cooperatives

In the field of electrical distribution, there are two remarkable phenomena. The first is the transformation of some local grid cooperatives into regional mega cooperatives with hundreds of thousands of members. The accumulated capacity in these mega cooperatives and their appetite for developing new business operations has clearly made them potential players in fields like offshore wind parks and capital-intensive experimental development projects like high-temperature geothermal. This might also have implications for cooperative involvement in emerging technologies like wave energy. The other phenomenon is the public perception of grid cooperatives as being more benevolent, democratic, or trustworthy vis-à-vis mainstream commercial energy firms. This is reflected in the national parliament's 2019 decision to sell Copenhagen's electrical distribution network – not to the highest-bidding commercial investor – but to a regional grid cooperative. It is important to note, however, that the parliament made a U-turn on this issue after substantial pressure from the public and much debate on the energy democracy-related theme of critical energy infrastructure and democratic control.

5.5 Discussion of key findings

The findings presented in this study do not give a monochrome picture of the effects of the industrial turn on Denmark's energy cooperatives. It rather illustrates how diverse different technologies and organizational forms develop at the time being. It provides a snapshot of the current cooperative energy landscape without showing exact direction of future transformations nor disclosing the actors and power figurations that might influence political agendas tomorrow. A potential bias is that much qualitative data comes from sources like the Danish Research Institute for Democratic Businesses or community energy activists or energy cooperatives that might overemphasize the contribution of cooperatives in energy supply. Also, the potentially significant dimension of interactions and cooperations between municipalities and energy cooperatives is not explored here. The findings suggest that political will in the form of incentives, support schemes, or mandatory non-profit models, are very important for the flourishing of community-based or cooperative energy projects in onshore wind power, farmers-owned biogas, or district heating. Logically, neoliberal drives to liberalize energy markets by dismantling such schemes or introducing market-based solutions in specific sectors can have disastrous effects on parts of the cooperative landscape. It is also clear, that popular mobilisations can have a direct impact on the political and legal framework for cooperatives, as exemplified in the case of the sale of Copenhagen's grid company Radius to a cooperative. At the same time, market actors do not always behave as political decisionmakers would like them to. Despite attempts to open the highly regulated energy sector to more commercial actors, recent years have also seen the growth of mega coops and the takeover of previously privately owned power plants by municipalities. The general tendency of politicians to favour more market-based solutions affects different technologies and different organizational forms at different times. Following this, more sophisticated models describing the characteristics of the industrial turn might be relevant for some technologies, and not for others. For example, the model developed by Kirch Kirkegaard et al. (2019) describing the core elements of the paradigm shift in Danish wind power – policies and incentives, technology change, size of investment required, and change in financing – might have explanatory power also in the case of biogas, but not necessarily in the case of solar power. It can be argued that there is not "one industrial turn" in renewables, but many. Or that the term industrial turn is not at all adequate to grasp the complexity of the transformations described in this paper. The findings of this study seem to support a point made by Krupnik et al. (2022) that every renewable technology has its own unique associated political economy. This is evident in the way the industrial turn impacts some, but not other, energy cooperatives.

It is outside the scope of this paper to investigate how the transformation of some cooperatives into something almost resembling industrial actors may influence the way democracy functions in these new mega cooperatives. But the new cooperative ownership regimes emerging in the context of renewable energy transitions seem like an important topic for future research. An exploration of actual and potential synergies in the wider cooperative eco-system, for example between social housing cooperatives and electrical grid cooperatives, also seems a promising theme.

6 Conclusion

This study shows that cooperatives play a substantial role in the energy system in Denmark and account for 26 percent of total turnover in the energy sector. Cooperatives play key roles in distribution of power and heat, as electric grid companies and district heating companies. Cooperatives also dominate the production of solar heating and biogas, and hold a large share of onshore wind power production. Additionally, coops contribute to research and innovation in emerging renewable technologies and organizational forms. The industrial turn in renewables has had a negative impact on farmer-owned biogas, and producer-owned solar and wind energy cooperatives. Wind coops have been most affected with four out of five wind cooperatives disappearing in a decade. Other forms of energy cooperatives are less affected, and some - like district heating coops - are thriving. A novel phenomenon is the rise of mega energy cooperatives, originating as local grid companies, with a variety of business activities. Several mega coops have more than 100,000 members, and the largest even has more than 10 percent of all households in Denmark as members. Large retail coops are also increasingly initiating large renewable energy projects. An untapped potential is identified in the large Danish cooperative housing sector where legal restrictions still stand in the way for a major buildout of rooftop solar. The findings suggest that comparative perspectives are valuable to better understand the potential for democratizing Europe's clean energy transition. The findings also have important consequences for the debate on scope and potential of grassroots innovations to develop sustainable energy systems, and particularly on the assessment of challenges and opportunities for the flourishing of renewable energy cooperatives.

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References

Allen, E., Lyons, H., & Stephens, J. C. (2019). Women's leadership in renewable transformation, energy justice and energy democracy:

Redistributing power. *Energy Research & Social Science*, *57*. https://doi.org/10.1016/j.erss.2019.101233

Bauwens, T., Gotchev, B., Holstenkamp, L. (2016). What drives the development of community energy in Europe? The case of wind power cooperatives, *Energy Research & Social Science*, *13*, 136–147.

Booker Nielsen, M. (2022). Identifying Challenges and Drivers for Deployment of Centralized Biogas Plants in Denmark. *Sustainability*, *14*(13), 8021.

Caramizaru, A., & Uihlein, A. (2020). *Energy communities: an overview of energy and social innovation*. Publications Office of the European Union.

Climate Justice Alliance (2022). Energy Democracy. https://climatejusticealliance.org/workgroup/energy-democracy

Dansk Fjernvarme (2020). *Fakta om fjernvarme* [Facts about district heating]. https://www.danskfjernvarme.dk/presse/fakta-om-fjernvarme

DE (2022a). Demokratisk Erhverv/ Danish Research Institute for Democratic Businesses. Rapport: Det erhvervsdemokratiske landskab – en kortlægning af demokratiske virksomheder i Danmark [Report: The business democratic landscape - a survey of democratic companies in Denmark]. https://demokratiskerhverv.dk/2022/03/rapport-det-erhvervsdemokratiske-landskab

DE (2022b). Demokratisk Erhverv/ Danish Research Institute for Democratic Businesses. Danmarks Demokratiske Virksomheder [Denmark's Democratic Companies].https://demokratiskerhverv.dk/danmarks-demokratiske-virksomheder

DGRV (2021). Deutscher Genossenschafts- und Raiffeisenverband. Energy Cooperatives in Germany. State of the Sector 2021 Report. https://www.dgrv.de/wp-content/uploads/2021/06/20210623_ENG_DGRV_Umfrage_Energiegenossenschaften_2021.pdf

EBO Consult (2020). Danmarks første borgerenergifællesskab [Denmark's first citizen energy community]. Ritzau. https://via.ritzau.dk/pressemeddelelse/danmarks-forste-borgerenergifaellesskab?publisherId=13560071&releaseId=13598186

EC (2019). European Commission. *Clean Energy for all Europeans.* Publications Office of the European Union, Luxembourg, 2019.

Elkjær, B. (2019, September 19). Så blev Radius alligevel solgt [Then Radius was sold anyway]. Information. https://www.information.dk/indland/2019/09/saa-radius-alligevel-solgt

Energistyrelsen (2008). Vindmøller i Danmark [Windmills in Denmark]. https://mst.dk/media/90030/vindmoeller-i-danmark_ens.pdf

Energistyrelsen (2021). Energistatistik 2020 [Energy statistics 2020]. https://ens.dk/sites/ens.dk/files/Statistik/energistatistik2020.pdf

Energistyrelsen (2022). Fakta om vindenergi [Facts about wind energy]. https://ens.dk/ansvarsomraader/vindenergi/fakta-om-vindenergi

Folketinget (2012). Udvalget for Landdistrikter og Øer. *Vindmøller som løftestang for lokaludvikling i udkantsområder* [Committee on Rural Affairs and Islands. Wind turbines as a lever for local development in outlying areas]. https://www.ft.dk/samling/20121/almdel/UL%C3%98/bilag/80/1212559.pdf

Forsyningstilsynet (2020). Fjernvarmestatistikken december 2019 [District heating statistics December 2019]. https://forsyningstilsynet.dk/media/7241/fjernvarmestatistik-2019_revideret.pdf

Frederiksen, U. G. (2018). Den danske elsektor frem til 1996. [The Danish electricity sector until 1996]. Danmarkshistorien. Aarhus University. https://danmarkshistorien.dk/vis/materiale/den-danske-elsektor-frem-til-1996

Gatto, A. (2022). The energy futures we want: A research and policy agenda for energy transitions. *Energy Research & Social Science*, *89*. https://doi.org/10.1016/j.erss.2022.102639

Gorroño-Albizu, L. (2021). *Ownership Models for Renewable Smart Energy Systems: Insights from Denmark and Sweden regarding Onshore Wind Farms and District Heating Systems.* Aalborg University.

Gorroño-Albizu, L., Sperling, K., & Djørup, S. (2019). The past, present and uncertain future of community energy in Denmark: Critically reviewing and conceptualising citizen ownership. *Energy Research & Social Science*, *57*. https://doi.org/10.1016/j.erss.2019.101231

Hulgård, L., Andersen, J., Nielsen, K. T., & Spear, R. (2022). *Demokratiske virksomheder. Kortlægning, landeundersøgelse og erhvervsfremme* [Democratic companies. Mapping, country survey and business promotion]. Erhvervsstyrelsen.

Hvelplund, F. (2013). Innovative democracy, political economy, and the transition to renewable energy: A full-scale experiment in Denmark 1971–2013. *Environmental Research, Engineering, and Management, 66*(4), 5–21. https://doi.org/10.5755/j01.erem.66.4.6158

ICA (2022). The International Cooperative Alliance. Cooperative identity, values and principles. https://www.ica.coop/en/whats-co-op/co-operative-identity-values-principles

IDA Teknologivurdering (2022, January 18). Ingeniørforeningen i Danmark – IDA Teknologivurdering med flere. Høring om borgerinddragelse i klima- og energipolitikken. Baggrundsnotat og præsentationer [The Danish Society of Engineers - IDA Technology Assessment and more. Consultation on citizen involvement in climate and energy policy. Background note and presentations]. Christiansborg. *

Jørgensen, A. P., Pedersen, M. S., Nayberg, F., & Bornakke, T. (2019). *Danmarks Demokratiske Virksomheder – Første kortlægning af fuldt demokratisk kontrollerede virksomheder* [Denmark's Democratic Companies - First survey of fully democratically controlled companies]. https://demokratiskerhverv.dk/wp-content/uploads/2021/03/Kortlaegning_Danmarks-Demokratiske-Virksomheder.pdf

KEFM (2021). Klima- energi- og forsyningsministeriet: 4 milliarder til grøn gas [Ministry of Climate, Energy and Utilities: 4 billion for green gas]. https://kefm.dk/aktuelt/nyheder/2021/dec/4-milliarder-til-groen-gas

Kirch Kirkegaard, J., Cronin, T., Nyborg, S., & Karnøe, P. (2021). Paradigm shift in Danish wind power: The (un)sustainable transformation of a sector. *Journal of Environmental Policy & Planning*, *23*(1), 97–113.

Kohl, U. (2022). Vedvarende energi og demokratiske virksomheder [Renewable energy and democratic enterprises]. In L. Hulgård, J. Andersen, K. T. Nielsen, & R. Spear (2022). *Demokratiske virksomheder. Kortlægning, landeundersøgelse og erhvervsfremme* [Democratic companies. Mapping, country survey and business promotion]. Erhvervsstyrelsen.

Kooij, H. J., Oteman, M., Veenman, S., Sperling, K., Magnusson, D., Palm, J., & Hvelplund, F. (2018). Between grassroots and treetops: Community power and institutional dependence in the renewable energy sector in Denmark, Sweden and the Netherlands. *Energy Research & Social Science*, *37*, 52–64.

Krupnik, S., Wagner, A., Koretskaya, O., Rudek, T.J., Wade, R., Mišík, M., Akerboom, S., Foulds, C., Stegen, K.S., Adem, Ç. & Batel, S. (2022). Beyond technology: A research agenda for social sciences and humanities research on renewable energy in Europe. *Energy Research & Social Science*, *89*. https://doi.org/10.1016/j.erss.2022.102536

Lazoroska, D., Palm, J., & Bergek, A. (2021). Perceptions of participation and the role of gender for the engagement in solar energy communities in Sweden. *Energy, Sustainability and Society*, *11*(1), 1–12.

Ingvardsen, J. (2022). Fjernvarmeformand: Prisen har måske nået toppen [District Heating Chairman: The price may have reached its peak]. LigeHer.

https://ligeher.nu/broenderslev/nyheder/livet-her/fjernvarme-formand-prisen-har-maaske-naaet-toppen/d8d55358-b3c6-4dab-b289-aa7935a24c2d

LØS (2022). Landsforeningen for Økosamfund. Om os [National Association for Ecological Society. About us]. https://okosamfund.dk/medlemmer

Markard, J. (2018). The next phase of the energy transition and its implications for research and policy. *Nature Energy* 3**,** 628–633. https://doi.org/10.1038/s41560-018-0171-7

Mendonça, M., Lacey, S., & Hvelplund, F. (2009). Stability, participation and transparency in renewable energy policy: Lessons from Denmark and the United States. *Policy and Society*, *27*(4), 379–398.

Mey, F., & Diesendorf, M. (2018). Who owns an energy transition? Strategic action fields and community wind energy in Denmark. *Energy Research & Social Science*, *35*, 108–117.

Novikau, A. (2022). Current challenges and prospects of wind energy in Belarus. *Renewable Energy*, *182*, 1049–1059.

Øyen, M. (2020). *Klimaminister vil fjerne loft over antallet af vindmøller på land* [Climate Minister will remove ceiling on the number of wind turbines on land]. *Altinget.* https://www.altinget.dk/artikel/194300-klimaminister-vil-fjerne-loft-over-antallet-af-vindmoeller-paa-land

Palm, J. (2021). The transposition of energy communities into Swedish regulations: overview and critique of emerging regulations. *Energies*, *14*(16), 4982.

REScoop (2022). European federation of citizen energy cooperatives. https://www.rescoop.eu

Rommel, J., Radtke, J., Von Jorck, G., Mey, F., & Yildiz, Ö. (2018). Community renewable energy at a crossroads: A think piece on degrowth, technology, and the democratization of the German energy system. *Journal of Cleaner Production*, *197*, 1746–1753.

Ruggiero, S., Busch, H., Hansen, T., & Isakovic, A. (2021). Context and agency in urban community energy initiatives: An analysis of six case studies from the Baltic Sea Region. *Energy Policy,* Volume 148, Part A, 2021.

Seyfang, G., & Haxeltine, A. (2012). Growing grassroots innovations: exploring the role of community-based initiatives in governing sustainable energy transitions. *Environment and Planning C: Government and Policy* 2012, *30*, 381–400.

Solomon, B. D., & Krishna, K. (2011). The coming sustainable energy transition: History, strategies, and outlook. *Energy Policy*, *39*(11), 7422–7431.

Tornbjerg, J. (2022). Geotermi kræver mere grøn strøm og udbygning af el-nettet. [Geothermal energy requires more green power and expansion of the electricity grid] *Green Power Denmark.* https://greenpowerdenmark.dk/nyheder/geotermi-kraever-mere-groen-stroem-udbygning-elnettet

von Wirth, T., Loorbach, D., Wagner, A., Koretskaya, O., Wade, R., Krupnik, S., Rudek, T., Foulds, C., Adem, C., Akerboom, S., Batel, S., Caspar Rabitz, F., Certoma C., Cherp, A., Chodkowska-Miszczuk, J., Denac, M., Dokupilová, D., Dotterud Leiren, M., Frolova Ignatieva, M., . . . Zapletalova, V., (2020). 100 Social Sciences and Humanities priority research questions for renewable energy in Horizon Europe. *Energy-SHIFTS*. https://doi.org/10.13140/RG.2.2.20556.28800

Wahlund, M., & Palm, J. (2022). The role of energy democracy and energy citizenship for participatory energy transitions: A comprehensive review. *Energy Research & Social Science*, *87*. https://doi.org/10.1016/j.erss.2021.102482

DAO meets the Estonian e-residency program: a stance from Synergy's blockchain-based open-source toolkit

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1 Introduction

Perez (2003, 2010) argues that we are in a long impasse period in the Information and Communication Technology (ICT) Age. The current techno-economic paradigm[8] has been implemented through financial speculation on the potential benefits of not fully understood digital technologies, using institutions and organisational models from the previous technological revolution[9] (the Age of Oil, the Automobile and Mass Production) (Perez, 2003).

Digital platforms are coopted by multinational corporations, mining data from their users using a massive intensive farming business model. Distributed ledger technology (DLT)[10] applications like blockchain are used as investors' bait for quick fundraising in Initial Coin Offerings (ICOs)[11] while providing little use. Similarly, other non-private actors like communities and governments aim to apply the promises of the ICT Age to other purposes. Platform Cooperativism[12] (platform co-ops) offers alternative organisational models for digital workers using the power of distributed networks. There are also government-backed initiatives: the Estonian government launched the e-Residency program supplying government-backed digital identity that provides access to non-nationals and non-residents to Estonia's digital services.

All the initiatives mentioned above are working in new arenas handicapped by the legacy of deeply embedded political-economy ideas about markets, business models, cooperation, and progress. As a result, each initiative breeds certain endemic dysfunctionalities. Digital proprietary platforms exploit their users as data-producing

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8 https://sociality.coop/
9 https://synergy-kit.io/
10 https://www.ngi.eu/ngi-projects/ledger/
11 The network effect is a phenomenon whereby increased numbers of people or participants improve the value of a good or service. https://www.investopedia.com/terms/n/network-effect.asp
12 For the definition of reputation systems and their evolution into token-based systems see https://future.com/reputation-based-systems/

digital livestock. Blockchains beget financial bubbles with enormous energy costs. Platform cooperatives are under-financed and isolated. The Estonian e-Residency program is nowhere near widespread adoption.
However, the findings from digital platforms and DLT (private), co-ops (grassroots) and the e-Residency program (public) are providing building blocks for a functional and sustainable networked digital ecosystem. Anyone with a terminal and an Internet connection can participate in a digital cooperative system, perhaps making a livelihood out of her/his skill and dedication while having access to a network of new contacts and opportunities for expanded collaborations.
Synergy is a blockchain-based toolkit developed by Sociality Digital Cooperative. Using the case study of *Synergy*, we will show how a digital cooperative can provide the backbone for a form of a fair global platform co-op giving valuable insights for modelling the post-capitalist grassroots global organisations to come. The authors argue that a co-op fostering a self-developed custom-made blockchain can become a fair global platform co-op in two steps: i) by implementing a Distributed Autonomous Organization (DAO) in the co-op and ii) by linking a DAO-enhanced platform co-op to government-backed digital services.

In this paper, we will explore how co-ops can constitute the base for deploying post-capitalist cooperative networks well adapted to thrive in the ICT Age:

1. We will present a theoretical framework with the main technological and organisational innovations supporting the enhancement of co-ops.
2. We will present the case of a co-op already presenting some of the described traits.
3. We will discuss the new proposed model of co-ops through the case study and the theoretical framework.
4. We will present some tentative conclusions.

2 Estonian e-Residency Program

Estonia is a small European country situated on the east side of the Baltic sea with a population of only 1.3 million inhabitants. After resuming independence in 1991, the Estonian government opted to develop a digital state (e-state) to catch up technologically with more advanced neighbouring countries. As one of the latest additions to the Estonian digital ecosystem, the Estonian e-Residency program, launched in 2014, supplies a government-backed digital identity providing access to Estonia's digital services (Korjus et al., 2017). The program aimed to increase the country's attractiveness as a business environment. However, from the targeted ten million e-residents by 2025, eight years ago, there were fewer than 100,000 e-residents at the beginning of 2022. The authors of this paper argue that the political-economy ideas underpinning the e-Residency program are chiefly built upon unquestioned economic principles resonating with the neoliberal phase of the capitalist expansion of financial markets. However, the e-Residency program provides valuable digital services that could be used under a different political-economy framework. Current benefits for e-residents include:

Establish and administer a company
Conduct all their banking
Declare taxes
Digitally sign contracts and other documents
Access international payment service providers (Kotka et al., 2016).

The aim of the e-Residency program has changed over the years. It began with a startup-like philosophy that, according to e-Residency program director Kaspar Korjus "will have to be supplanted by a more stable framework as the programme matures" (Korjus 2018). One of the e-Residency program founders stated in 2019 that the initial idea turned into offering "the Estonian business environment to the entire world" to increase Estonian revenues from business abroad. Moreover, the program evolved into a "national initiative in Estonia based on cooperation between the public and private sector" (Korjus 2018, 2). In other words, the aim shifted into using Estonian digital public services to attract foreign companies to establish themselves in the European Union, using Estonia as a proxy country where they operate international businesses with reduced costs and minor bureaucracy burdens.

Gathering revenue and providing an ecosystem of digital services, both public and private, for foreign companies has overlooked other possible e-residency target groups, like co-ops, foundations, and other non-profit enterprises. However, another category is mentioned in the e-Residency 2.0: the digital nomads, people earning a living by working online without a fixed business location.

Uses of blockchain technology in the e-Residency program have been explored, as in the case of the "public notary service to Estonian e-residents based on blockchain technology" (Sullivan and Burger 2017). Regarding blockchain and e-residency, decentralized, cryptographically signed proof of existence for identities and the potential for individuals to control access to their identity information" are significant benefits to blockchain that, like e-residency itself, herald the near future in identity management and authentication. Still, its application is untested, and the ensuing implications are not fully known" (Sullivan and Burger 2017). Ultimately, e-residency may be (accidentally?) a tool for global digital citizenship (Tammpuu and Masso 2019). Moreover, in the case of Estonia Identity Documents (ID) services, the state is seen as a market actor providing services to 'global citizens' in a global digital market and as a membership organization extending beyond its physical frontiers by providing access to its digital service ecosystem to citizens of other states (Tampuu et al., 2022).

3 Distributed Autonomous Organization (DAO)

The decentralised infrastructure underlying Bitcoin has become increasingly relevant in multiple fields since the publication of the Bitcoin whitepaper (Nakamoto, 2008). In the following section, we provide an overview of Blockchain technology and some of the changes and new organisational models that it has brought about. We also add a sub-chapter dealing with government projects using Blockchain.

3.1 Blockchain & Blockchain-based Systems

Blockchain is a distributed ledger technology that enables immutable and decentralised data storage and computation without a third trusted party (Underwood, 2016; Wright & De Filippi, 2015; Rozas *et al.*, 2021). Blockchain enables the decentralised implementation of infrastructure-level properties and allows the storage of code fragments known as smart contracts (Rozas *et al.*, 2021; Semenzin *et al.*, 2022).

A set of smart contracts deployed on a public blockchain constitutes a Decentralized Autonomous Organization (DAO). The information encoded in these smart contracts defines the governance structure of the DAO blockchain-based system. Since smart contracts allow parties to verify whether a condition has been met, they mediate the interaction between the parties. Thus, they enable members of the organization to coordinate and self-govern decentrally, horizontally, transparently and securely (Wright & De Filippi, 2015; Hassan & De Filippi, 2021).

Decentralisation in DAOs concerns both the infrastructure on which they rely and governance. Autonomy is based on the property of smart contracts to be executed without human intervention and grants DAOs independence from their developers while guaranteeing continuity as long as at least one of the conditions required by the set of smart contracts is fulfilled (Faqir-Rhazoui *et al.*, 2021).

Autonomous automatisation (Rozas *et al.*, 2021; Semenzin *et al.*, 2022) provides new possibilities, such as encoding redistributive algorithms into smart contracts. When a smart contract is executed, these algorithms redistribute profits or tasks between the involved parties. Tasks and remuneration can thus be transparently and automatically assigned on the basis of standardised criteria or objective scales.

3.2 Blockchain-based government projects

Blockchain imaginaries can be classified into crypto-anarchist and crypto-institutionalist imaginaries (Husain, 2020; Semenzin *et al.*, 2022). The former advocates blockchain's potential to subvert government institutions, while the latter advocates its potential to strengthen those institutions through government-led blockchain projects (Semenzin *et al.*, 2022).

Under the latter imaginary, it has been argued that features of blockchain such as decentralisation, data quality and data integrity, transparency and immutability could play a central role in the fight against fraud and corruption in the public sector (Batubara *et al.*, 2018; Ølnes *et al.*, 2017) while decreasing costs (Alexopoulos *et al.*, 2019) and maximizing performance (Diallo *et al.*, 2018). However, the potential of blockchain in the government field is just beginning to be explored.

DAOs have been proposed as candidates to improve the contracting service of an e-government system. DAO-enhanced e-government systems or government-DAOs (eGov-DAOs) rely on a public blockchain and allow real-time monitoring, providing transparency, accountability, immutability and improving the national resource management of the service while solving security problems (Diallo *et al.*, 2018).
Proposals incorporating blockchain into e-government systems have not been limited to institution-citizen interactions but also encompassed government-to-government (G2G) services. Geneiatakis *et al.* (2020) proposed and experimentally evaluated the performance of a System for Exchange of Excise Data (SEED) implementation on the blockchain. SEED is part of the Excise Movement and Control System (EMCS), which controls the movement of excisable goods across EU Member States' borders.
Despite the abundance of theoretical proposals, concrete applications are scarce. The following are some examples of ongoing initiatives. The Chinese district of Chancheng, through "The Comprehensive Experimental Area of Big Data in Guangdong Province" project, applies blockchain to digital identity, credit, and information disclosure avoidance (Hou, 2017). Similarly, the e-Estonia e-government system uses permissioned/closed blockchain to strengthen traditional centralised institutions (Semenzin *et al.*, 2022). Finally, the German Federal Office for Migration and Refugees (BAMF) has launched a project to promote collaboration between governmental agencies through blockchain. Its main goal is to improve the efficiency of information resources on migration and asylum procedures (Kassen, 2022).

4 Platform Cooperativism

The emergence of platform cooperativism is a result of the massive deterioration of labour conditions associated with platform capitalism (Mazzucato, 2018; Scholz, 2016). Platform co-ops derive from applying the co-op concept to the digital environment (Scholz, 2016; Pazaitis *et al.*, 2017). They provide an alternative organisational model for digital workers based on the main idea of shared ownership and democratic governance.
Although there is no consolidated and unanimously accepted taxonomy of platform co-ops, Borkin (2019) suggests the following:

1. Multi-stakeholder/community platforms: combine two or more categories of member-owners (usually users, producers and developers).
2. Producer-led platforms: composed of stand-alone producers as member-owners selling their products and services and addressing the governance of the platform.
3. Consortia/worker platforms: the member-owners are the workers/employees. They not only work but also govern the platform.
4. Data consortia platforms: built to manage its members' data for mutual benefit.

Despite differences, they all embrace common founding principles (Scholz & Schneider, 2016): a) anti-discriminatory open membership; b) democratic member control; b) equitable member economic participation; d) autonomy and independence; e) education, training, and information; f) cooperation among cooperatives; g) concern for the community.

Combining activism and work (Pazaitis *et al.*, 2017), platform co-ops aim to provide technological, cultural, political and social changes (Scholz, 2016). Beyond profit generation, these changes and the generation of a fair alternative to platform capitalism are their main goals (Sandoval, 2020).

5 Synergy

Sociality Digital Cooperative is a producer-led digital co-op based in Athens[13]. Its main objective is to provide a solid online presence, digital tools and infrastructure to its clients. Imbued with open source values and work ethic, Sociality encourages the use of open source and places special emphasis on the fair treatment of data.

Synergy Toolkit is a financial open-source toolkit for cooperatives developed by Sociality and based on a distributed ledger[14]. It was funded by the NGI Ledger program[15], an initiative of the European Commission. *Synergy* provides loyalty and micro-credit services to cooperatives (and other small and medium-sized enterprise (SME) sectors and businesses) using blockchain technology. The objective is to help communities overcome challenges such as lack of liquidity, investment capacity, and client acquisition.

The system was co-designed by the co-op community in Athens during meetings and workshops. It operates using the Quorum open-source blockchain platform. Moreover, the system has its own digital wallet and implements privacy-by-design elements to ensure data privacy for the user. The final goal was to make the toolkit easily replicable, maintainable, and modular so communities can recreate it in different cities and govern it in a community-based approach. When interacting with *Synergy*, a user interacts with the following *Synergy Public Components*:

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13 A techno-economic paradigm is a best practice model for the most effective use of the new technologies within and beyond the new industries emerging from a technological revolution. (Perez, 2010)

14 What distinguishes a Technological Revolution are two basic features: a) the strong interconnectedness and interdependence of the participating systems in their technologies and markets; b) the capacity to transform profoundly the rest of the economy (and eventually society). (Perez, 2010)

15 Distributed ledger technology (DLT) has established itself as an umbrella term to designate multi-party systems that operate in an environment with no central operator or authority, despite parties who may be unreliable or malicious ('adversarial environment'). Blockchain technology is often considered a specific subset of the broader DLT universe that uses a particular data structure consisting of a chain of hash-linked blocks of data. (Rauchs *et al.,* 2018)

-Wallet. A digital wallet for supporters and merchants, available on the web and mobile.

-Blockchain. A quorum blockchain infrastructure.

-Public Website. A public website to engage supporters.

-Cardboard Card. Integration with Quick Response (QR) codes for non-digital users.

Synergy's goal is to support the co-op community and create an interconnected platform tailored to their collective needs. The tool's purpose is to empower the collectives both structurally and financially. Thus it was crucial for *Synergy* to focus on the community itself and the relationship dynamics inside it through a co-design process.

In order to effectively design the procedure, it was deemed necessary to assess the relationships inside the co-op community of Athens in terms of a network. That was achieved by holding meetups and researching collective operations with the intention to form an open-to-contribution and debate co-design process about the needed change and describing the technical solution and its feasibility.

After the meetups and the co-design sessions came the planning of the implementation of the proposed change consisting of the following parts: propagate, test, document and release change.

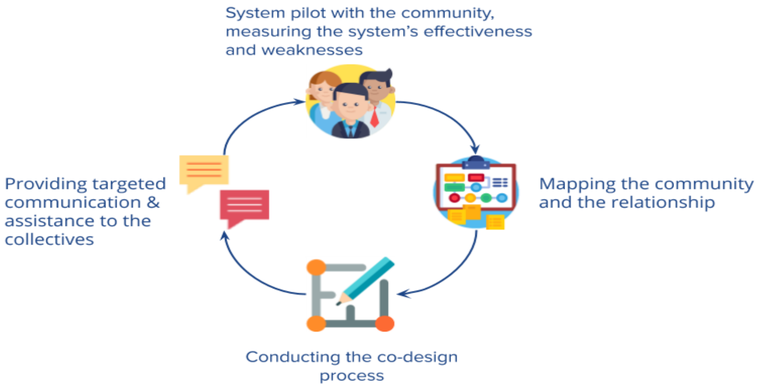

Fig. 1. Methodology Cycle[16]

The following actions were deemed necessary in terms of methodology:

- Mapping the community and the relationship of its members, through meetups, focus and research groups, operation analysis and more.
- Conducting the co-design describing the proposed solution and the implementation plan.

16 An initial coin offering (ICO) is the cryptocurrency industry's equivalent to an initial public offering (IPO). A company seeking to raise money to create a new coin, app, or service can launch an ICO as a way to raise funds. Interested investors can buy into an initial coin offering to receive a new cryptocurrency token issued by the company. This token may have some utility related to the product or service that the company is offering, or it may just represent a stake in the company or project. https://www.investopedia.com/terms/i/initial-coin-offering-ico.asp

- Separate the features of *Synergy* into independent and interchangeable modules.
- Providing targeted communication & assistance to the collectives and the parties involved - in the form of materials and training.
- Creating a system pilot with participants from the community, measuring the system's effectiveness and weaknesses and redesigning its functions accordingly.

5.1 The Synergy Solution

5.1.1 Synergy Services and Contributions

The general goal of *Synergy Services and Contributions* (SSC) is to improve efficiency levels. In order to be able to contribute to the growth of co-ops, *Synergy* mapped and addressed critical obstacles in *Synergy Toolkit's* services.

Table 1. Synergy Services and Contributions to Growth Barriers

Growth Barrier	Synergy Service	Synergy Contribution
Accessing appropriate finance	Microfunding	Tokenization or future/network products/services as means of funding
Regulations / Administrative Burdens	Community Building	Involvement and empowerment of structures and collective bodies such as the SSE Union in Athens
Lack of awareness	Community Loyalty	Raising awareness through a marketing campaign and platform for the general public.
Lack of a tradition of cooperation	Community Building & Loyalty	Creation of a Common Service Pool and documentation on business support

Beyond mere means of transactions, *Synergy Toolkit* aims to create a circular, self-sustaining, and added-value community that will promote economic growth through cooperation and eventually commoning.
Additionally, the toolkit represents the community and depicts its ethical and affective values. Taking that into account, we focus on the Social and Solidarity Economy (SSE) as a community but also on the audience/customers that they interact with and partially share some of the values the collectives embody.

5.1.2 Community Loyalty Program

A community loyalty program involves businesses in a specific sector pooling their resources together to promote themselves and reward their customers. The desired goals of a community loyalty program are to lower service costs and reduce price sensitivity while generating higher purchasing levels, and positive word-of-mouth.

5.1.3 Microfunding

The micro-funding concept provides solutions regarding both investment capital and liquidity injections. A future microcredit scheme could be developed where the consumers purchase tokens representing products in order to provide the cooperatives with the capital they need in order to make investments. It entails two aspects: exchange of capital with tokenization of future services/products; donations and crowdfunding from supporters.

5.1.4 Community Transactions

In order to enhance the collective governance and the community building between co-ops themselves and co-ops and supporters, the following items were included in *Synergy's* initial minimum viable product (MVP). Initially, the co-ops were given the ability to post their news, events, or support requests so that they could attract and inform supporters about their activities. The ability to post feature was developed to allow co-ops to showcase their social impact and activities.

Moreover, the MVP included a draft community area where co-ops could post news, events and requests that would be visible to other co-ops only. The draft community area would provide the basis for developing the third major service of *Synergy* regarding community transactions. During the co-design phase and the workshop, the draft community area raises a debate regarding the possibility of using it as an internal lending mechanism.

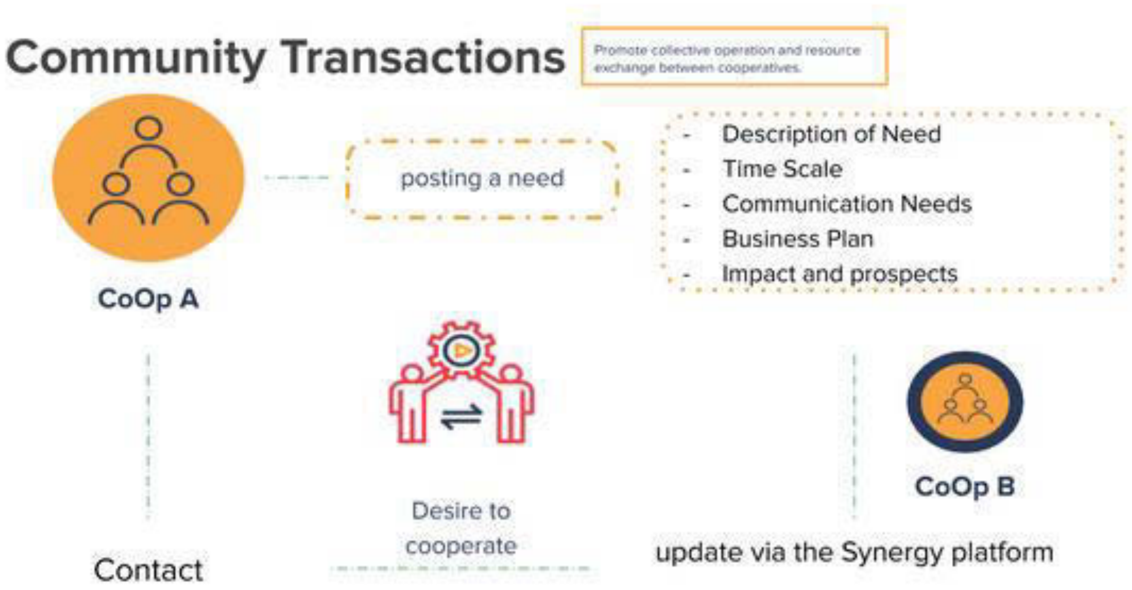

Fig. 2. Community Transactions

Such a discussion highlighted the need for a forum for internal communication to develop solidarity between co-operatives and as a practical experiment on whether it would be feasible to set up an internal lending fund where members of co-ops could develop internal rules and methods to decide on fund allocation and prioritization of needs and requests inside the co-ops. The co-design phase concluded that borrowing could in addition to money refer to services or know-how.

5.2 Services and Features

Synergy Toolkit is at the same time the backbone and the tools used to generate more communities and applications. Sociality has developed a pilot MVP called Synergatika.gr with specific features for each of the main services, providing a custom-made product that responds to the situation of the Athens cooperative community, as recalled during the co-creation sessions with the local community.

In the following Table, there is a condensed version of all available features of the services that can be provided to new communities.

Table 2. Synergy CoDesign Cards

Service	Feature	Description
Loyalty	Redeem Points	As long as the member is shopping, he/she earns points that he/she can spend
Loyalty	Points-based Discount	As long as the member is shopping, he/she earns points and he/she receives a discount
Loyalty	Points for Gifts	As long as the member is shopping, he/she collects points and he/she receives gifts
Loyalty	Discount	Members are discounted from the start as they show their card
Loyalty	Gamification	Members get points based on their behavior. Those who gather more earn specific benefits
Loyalty	Reference	When bringing in a new member earns points
Loyalty	Offers	Members are privileged for specific offers
Microfunding	Donations	Supporters give money as donations
Microfunding	Crowdfunding with gifts	Supporters give money for something and get back specific gifts
Microfunding	Subscribers	Supporters give specific money every month and get gifts back
Microfunding	Lending with Points	Supporters give money for something and get the equivalent in points they can spend in the store
Microfunding	Microfinance with Money	Supporters give money and get money in future time
Microfunding	Liquidity Fund	Microfunding contributions go into a common

		liquidity fund
Community Transactions	Internal Lending	Cooperatives lend to each other
Community Transactions	Negative Balance	Cooperatives have the potential for a negative balance in a domestic currency
Community Transactions	Smart Contracts	Cooperatives make ad hoc agreements with each other on products or services
Community Transactions	Liquidity Fund	A common liquidity fund is created from the cooperatives to help each other.

5.3 Value Chain & Benefits

A value chain "describes the full range of activities that are required to bring a product or service from conception, through the intermediary phases of production (...), delivery to final consumers, and final disposal after use" (Kaplinsky, 2000). Small businesses usually face problems when participating in a value chain. Scarce resources and capacity result in difficulties for small enterprises to become suppliers to larger audiences, compete in value chains and enter higher value markets. While large firms can often use their bargaining power in their supply chain, small enterprises need to follow the decisions taken by others. In this context, they end up with no other choice than to accept prices or product requirements that are given by a buyer.

A generic value chain has many levels of involvement and several trade connections where intermediary traders play a crucial role, often having concrete market information and more financial resources than small producers. A trader can relate to each of the small producers individually and can potentially use his bargaining position to exercise pressure on small producers (for lower prices etc).

This asymmetric bargaining power in a chain lowers small producer revenues and, thus, limits their opportunities for improved livelihoods. Producers often do not have proper information on market conditions and processes and therefore run the risk of being treated unfairly.

An organization can be linked to a value chain both vertically (buyer-seller relationships) and horizontally (internal operation and coordination, linkages to services providers and to policymakers). *Synergy* aims to become the center of a new and integrated value chain for the cooperatives where it will be possible to address the problems of the traditional value chain.

Synergy offers the following benefits to the cooperatives and their clients:

A. It is creating a community and a marketplace where it is possible to raise awareness and interaction between the interested parties.

B. It is possible to gain access to services that can be crucial for the business development of their activities.

Synergy's MVP (Synergatika.gr) is testing a new and more integrated value chain for cooperatives where vertical and horizontal relationships are facilitated. Cooperative communities will be able to: facilitate and leverage market linkages, improve their collective bargaining power and gain market information and intelligence.

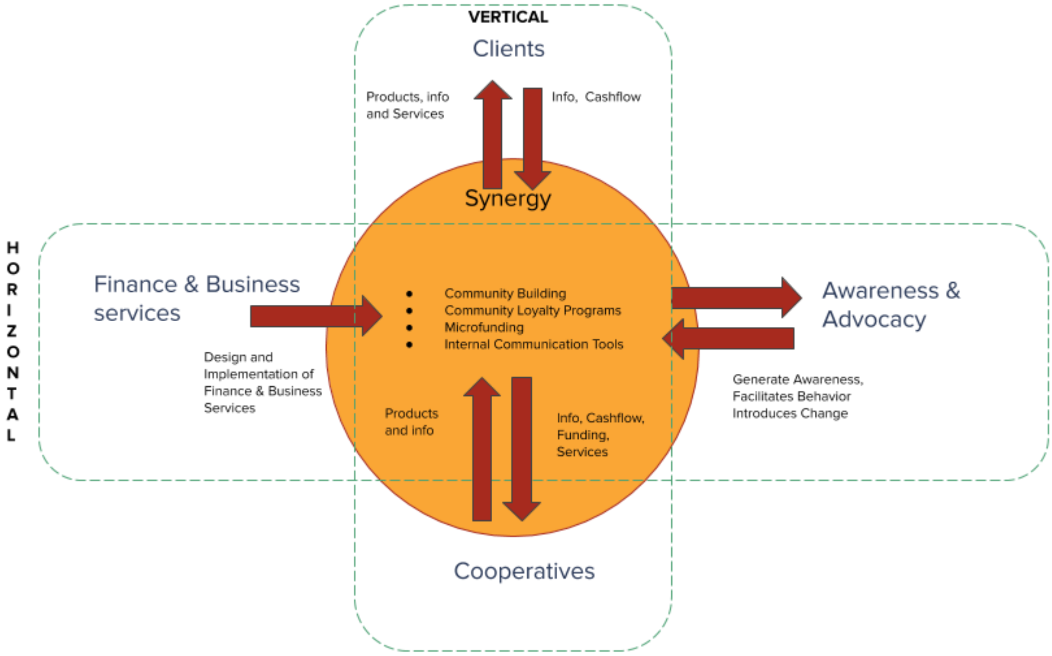

Fig. 3. Integrated Value Chain

The relationship between cooperatives and clients is channelled through the application marketplace. Additionally, the vertical relationship is being expanded adding to it the notion of micro-funding and community loyalty where the client/supporter becomes a more vital asset to the operation of the cooperative. The horizontal relationship between *Synergy* and the cooperatives reduces common costs and activities.

Namely, the design and implementation of communal finance and business services create economies of scale between the cooperatives and lowers externalities.

Finally, the platform provides the ground for collective advocacy and raising awareness for the community which later can create benefits for the community in general.

6 Discussion

Platform cooperativism has the potential to provide key organizational innovations for the reality that lies ahead: a post-Globalization era. The subjacent logic and ethos of the ICT Age greatly influence how the generation and allocation of resources, organizational and business models and even institutions operate, making them over-dependent on digital technologies and their underlying principles. Such "digital logic" permeates novel practices like peer production, open-source, asynchronous collaboration, modularization of tasks, or iterative version control processes. These practices present key factors for massively distributed innovation and collaboration and imitating computers and software in many ways. The simpler the rules of engagement, the more likely multiple agents will engage in sharing information between themselves. If the agents achieve enhanced communicative capacities, individual members of digital networks can generate so-called "network effects"[17] by seer numbers and density of cooperation. The rules, values and aims of platforms co-ops make them suitable candidates to articulate intensive and extensive digital information exchanges. As co-op members are collaborative equals (peers), they are well fit to interoperate in distributed networks. If platform co-op members would have the capacity to generate, pool, invest and exchange resources together, heeding equal and horizontal rules, co-prosperity should be an expected outcome of their collaboration. The tools and mechanisms needed for such platform co-op co-generated prosperity to happen are already available, although not in their mature phase yet.

Knowing that a DAO is the application of rules in software that self-executes itself and that for implementing a DAO, a blockchain is needed in the first place, we see that *Synergy* has the building blocks for implementing a DAO over platform co-ops. Implementing a DAO in platform co-ops to provide a clear set of rules to register and operate actions and activities from the platform co-ops and their members would provide a transparent and reliable source of trust between communities organized in co-ops. *Synergy Services and Contributions* is already incorporating the feedback from the local co-op in Athens about the barriers preventing their members from using a co-op-based blockchain to have access to finance or surpass local and national administrative burdens. *Synergy Services* built over the Quorum blockchain can be included in the rules for a DAO. The conditions to access financial instruments like microcredits can be executed automatically. When a co-op member's financial request fills the encoded conditions, or when the data of a co-op member is used for administrative procedures, the DAO would automatically accept the financial request and transfer the funds or send the data to the pertaining administrative body.

Synergy Toolkit constitutes the first approach of platform co-ops to the Blockchain environment. The set of three digital tools on the toolkit is the entry point for the Athens co-op into the realm of DAO. First, the wallet upgrades the members' financial capacity

17 Platform cooperativism is about democratic ownership models for the Internet. (Scholz, 2016)

to interact with digital tokens and cryptocurrencies, adding a new layer to their digital persona for accessing digital sources of financial support. Second, the blockchain provides the trusted backbone for all digital operations to be correctly registered, transparent, and secure. Third, the website provides a platform with publicly available information for co-op members, supporters and related parties and a digital forum for discussion, questions & answers (Q&A), and connecting with other co-op members. Any co-op member that can properly use these three digital tools provided by *Synergy* would have no significant impediments to being part of a co-op DAO.

Synergy Toolkit is integrated by a Digital Wallet and deployed in a Quorum Blockchain infrastructure: a permissioned ledger implementation built from Ethereum code. Since *Synergy* is deployed on Quorum, only authorized nodes within the network can connect. In addition, Quorum supports the implementation of smart contracts. The execution of these smart contracts and transactions and access to the information encoded in the ledger are restricted to authorized nodes.

The possibility of encoding the governing rules of platform co-ops in smart contracts opens up new opportunities. In the case of Sociality, Quorum blockchain allows implementation of the rules governing the digital co-op itself and many of the features of the *Synergy Toolkit*. The resulting DAO-enhanced platform co-op could function internally as an autonomous infrastructure. Such infrastructure would enable modularized task distribution, secure, transparent transactions; and unbiased automatized allocation of community loyalty program resources and microfunds through redistributive algorithms. Finally, the smart contract's code could be inheritable, enabling self-replication of both the digital platform and the toolkit.

Synergy's Community Loyalty Program generates value in two complementary ways: on the one hand, generating engagement by providing the cooperative's customers with loyalty benefits, and on the other hand, encouraging the investment of resources within the cooperative's network. These two features are mutually reinforcing, contributing to sustaining the livelihoods of platform co-op members and ensuring the survival of the platform co-op and its network. Furthermore, implementing *Synergy's Community Loyalty Program* rules in a DAO-enhanced platform co-op smart contracts guarantees an autonomous, fair and unbiased application. Encoded automatized redistributive algorithms take care of allocating resources among the involved parties or the network. Eventually, loyalty programs encoded in a DAO can be the cornerstone for token-based reputation systems[18] serving as performance indicators of platform co-op members' performance. Platform co-op members investing their time and effort inside the co-op ecosystem would be rewarded for re-investing in the community. In this sense, a well-designed token-based reputation system can also help activate and enhance network effects inside the platform co-op.

18 All figures and tables in this paper have been elaborated by the authors.

A situation like the previously described would apply to local co-op members, joint efforts between different co-ops, and digital nomads. Especially in the case of the latest, having no fixed location presents some practical difficulties. Partaking in several different public administration systems, bureaucratic processes, multiple identity registrations, tax arrays, and social security systems is an advantage in many ways but also presents handicaps: not having a fixed territory where to be fully accountable, but instead belonging to several different administrative jurisdictions sequentially over time or simultaneously (citizenship, permanent residency, tax residency, seasonal residency, Etc.) derives in fragmentation of identity. The Estonian e-Residency program provides the missing part for DAO-enhanced platform co-ops: a legal backbone in a well-reputed (digital) state and access to its public and private services for e-residents. When part of the e-Residency program, digital nomads are always connected to the Estonian administrative system regardless of their current nationality or residency status.

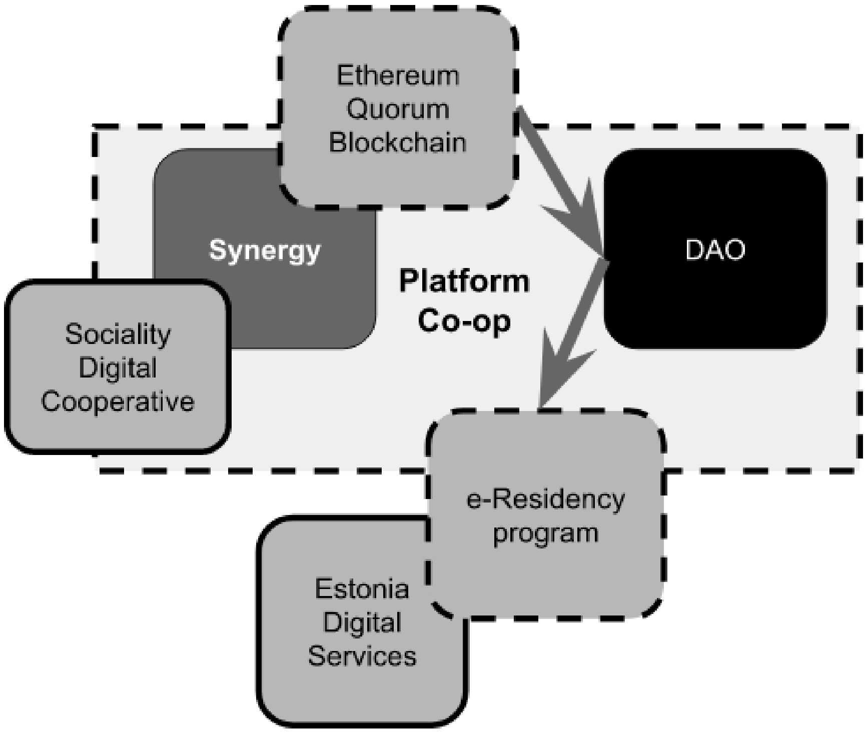

Fig. 4. e-Residency DAO-enhanced platform co-op for Sociality Digital Cooperative

DAO-enhanced platform co-ops could function as an interface, linking its members with the Estonian administrative system through the e-Residency program. Having the DAO-enhanced platform co-op members registered under the same state digital legislative framework, the collective management of resources produced by the platform co-op members located globally should be significantly simplified. Specifically, nearly all services the government delivers in Estonia are digitized, opening a path for algorithms to operate in Estonia's e-state environment. Moreover, these DAO-enhanced platform co-ops could encode in smart contracts the legislation and procedures regarding workers' rights, occupational categories, taxation and insurance and payment systems, among other parameters. The stored code and its execution would be available for every platform co-op member. Hence, the DAO would function as an automatized interface between Estonian digital services and platform co-op members.

Redistributive algorithms encoded in a DAO can allocate resources between platform co-op members and automatise administrative processes like taxes or sick leave applications. After completing a job, the DAO algorithm would identify the resources produced and allocate them between the platform co-op members, the e-Tax office in Estonia, and other institutions. The complementarity between platform co-ops, DAO and the e-Residency program would enable post-precarity features for digital workers. Furthermore, the automatisation of tasks would relieve platform co-op members from burdensome administrative processes by using a state-of-the-art administrative system and digital technologies. There is a significant possibility of DAO-enhanced platform co-ops potentially playing a role in the future development of post-precarious digital work.

Finally, by having secure, accessible and transparent encoded sets of rules for co-ops, a new breed of organisation (e-residency DAO-enhanced platform co-op) would be born. Despite operating in different digital and national spaces, anyone willing to comply with the platform co-op rules could become a member. This global community (or association of communities) operates under the same rules in a truly distributed network, helping to unlock and evolve, perhaps, a blueprint for post-capitalist grassroots global organisations.

7 Conclusion

Platform co-ops feature salient characteristics for potentially becoming blueprint global horizontal organizations for a post-Globalization ICT Age. Even if platform co-ops lag behind corporate platforms in technological development and user adoption, leapfrogging current platform ecosystems by adopting state-of-the-art digital organizational models such as DAO and the e-Residency program is a real possibility. The internal logic of the key technology components of the ICT Age (computers and the Internet) determines the path for best organizational and business practices. Some characteristics that differentiate digital and pre-digital organizational practices (such as modularization, cooperation, communicational density and other features) showcase better adaptability for the ICT Age best practices and organizational models (platforms, co-ops, DLT).

Local co-ops like Sociality Digital Cooperative or global digital workers like the digital nomads are potentially the core members of a new cooperative model described as an e-residency DAO-enhanced platform co-op. We have shown through the case of

Synergy that platform co-ops are already developing tools and practices for scaling into distributed network ecosystems.

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References

Alexopoulos, C., Charalabidis, Y., Androutsopoulou, A., Loutsaris, M.A. and Lachana, Z., 2019. Benefits and obstacles of blockchain applications in e-government.

Batubara, F.R., Ubacht, J. and Janssen, M., 2018, May. Challenges of blockchain technology adoption for e-government: a systematic literature review. In *Proceedings of the 19th Annual International Conference on Digital Government Research: Governance in the Data Age* (pp. 1-9).

Borkin, S., 2019. Platform co-operatives–solving the capital conundrum. *NESTA: London, UK*.

Diallo, N., Shi, W., Xu, L., Gao, Z., Chen, L., Lu, Y., Shah, N., Carranco, L., Le, T.C., Surez, A.B. and Turner, G., 2018, April. eGov-DAO: A better government using blockchain based decentralized autonomous organization. In *2018 International Conference on eDemocracy & eGovernment (ICEDEG)* (pp. 166-171). IEEE.

Faqir-Rhazoui, Y., Arroyo, J. and Hassan, S., 2021. A comparative analysis of the platforms for decentralized autonomous organizations in the Ethereum blockchain. *Journal of Internet Services and Applications*, *12*(1), pp.1-20.

Geneiatakis, D., Soupionis, Y., Steri, G., Kounelis, I., Neisse, R. and Nai-Fovino, I., 2020. Blockchain performance analysis for supporting cross-border E-government services. *IEEE Transactions on Engineering Management*, *67*(4), pp.1310-1322.

Hassan, S. and De Filippi, P., 2021. Decentralized Autonomous Organization. *Internet Policy Review*, *10*(2), pp.1-10.

Hou, H., 2017, July. The application of blockchain technology in E-government in China. In *2017 26th International Conference on Computer Communication and Networks (ICCCN)* (pp. 1-4). IEEE.

Husain, S.O., 2020. *(De) coding a technopolity: tethering the civic blockchain to political transformation* (Doctoral dissertation, Wageningen University and Research).

Kaplinsky, R., 2000. Globalisation and unequalisation: what can be learned from value chain analysis?. Journal of development studies, 37(2), pp.117-146.

Kassen, M., 2022. Blockchain and e-government innovation: Automation of public information processes. *Information Systems*, *103*, p.101862.

Korjus, K., 2018. E-Residency 2.0 White Paper. https://s3.eu-central-1.amazonaws.com/ereswhitepaper/e-Residency+2.0+white+paper+English.pdf

Korjus, K., Castillo, C. and Kotka, T., 2017, April. Perspectives for e-Residency strenghts, opportunities, weaknesses and threats. In 2017 Fourth International Conference on eDemocracy & eGovernment (ICEDEG) (pp. 177-181). IEEE.

Kotka, T., Castillo, C. and Korjus, K., 2016, September. Estonian e-Residency: benefits, risk and lessons learned. In International Conference on Electronic Government and the Information Systems Perspective (pp. 3-15). Springer, Cham.

Mazzucato, M., 2018. *The value of everything: Making and taking in the global economy*. Hachette UK.

Nakamoto, S., 2008. Bitcoin: A peer-to-peer electronic cash system. *Decentralized Business Review*, p.21260.

Ølnes, S., Ubacht, J. and Janssen, M., 2017. Blockchain in government: Benefits and implications of distributed ledger technology for information sharing. *Government Information Quarterly*, *34*(3), pp.355-364.

Pazaitis, A., Kostakis, V. and Bauwens, M., 2017. Digital economy and the rise of open cooperativism: the case of the Enspiral Network. *Transfer: European Review of Labour and Research*, *23*(2), pp.177-192.

Perez, C., 2003. Technological revolutions and financial capital. Edward Elgar Publishing.

Perez, C., 2010. Technological revolutions and techno-economic paradigms. Cambridge journal of economics, 34(1), pp.185-202.

Rauchs, M., Glidden, A., Gordon, B., Pieters, G.C., Recanatini, M., Rostand, F., Vagneur, K. and Zhang, B.Z., 2018. Distributed ledger technology systems: A conceptual framework. Available at SSRN 3230013.

Rozas, D., Tenorio-Fornés, A., Díaz-Molina, S. and Hassan, S., 2021. When Ostrom meets blockchain: exploring the potentials of blockchain for commons governance. *SAGE Open*, *11*(1), p.21582440211002526.

Sandoval, M., 2020. Entrepreneurial activism? Platform cooperativism between subversion and co-optation. *Critical Sociology*, *46*(6), pp.801-817.

Scholz, T., 2016. Platform cooperativism. *Challenging the corporate sharing economy. New York, NY: Rosa Luxemburg Foundation*.

Scholz, T. and Schneider, N., 2016. Ours To Hack and Own: The Rise of Platform Cooperatives.

Semenzin, S., Rozas, D. and Collado, S.H., 2022. Blockchain-based application at a governmental level: disruption or illusion? The case of Estonia. *SocArXiv. March*, *3*.

Sullivan, C. and Burger, E., 2017. E-residency and blockchain. computer law & security review, 33(4), pp.470-481. doi: 10.1016/j.clsr.2017.03.016

Tammpuu, P. and Masso, A., 2019. Transnational digital identity as an instrument for global digital citizenship: The case of Estonia’s e-residency. Information Systems Frontiers, 21(3), pp.621-634.

Tammpuu, P., Masso, A., Ibrahimi, M. and Abaku, T., 2022. Estonian e-residency and conceptions of platform-based state-individual relationship. TRAMES: A Journal of the Humanities & Social Sciences, 26(1), pp. 3–21.

Underwood, S., 2016. Blockchain beyond bitcoin. *Communications of the ACM*, *59*(11), pp.15-17.

Wright, A. and De Filippi, P., 2015. Decentralized blockchain technology and the rise of lex cryptographia. *Available at SSRN 2580664*.

Shifting the Power Balance: community-led resistance and the shaping of local understandings of place

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Abstract. Past energy transitions have been characterised by strategic geopolitical and socio-economic drivers that rarely considered issues of social justice or community cohesion. This is interesting given the profound systemic reconfigurations that took place. The current transition to low-carbon energy has seen a departure of sorts, particularly in terms of the complex, intersecting drivers involved. Consequently, there has been a widening of the roles citizens are expected to take, particularly in terms of participation and engaging with the energy system. However, differing interpretations of how these roles are to be expressed, and the degree of power to be assigned those roles, has resulted in contradicting responses from local people. The rollout of what appear to be broadly popular renewable energy technologies has met with strong resistance at the local level. Place attachment – especially in terms of belonging, identity, relationships, and acceptance – has come to define localised responses to recent (inter)national energy and climate-related policy. Understanding how place attachment affects the (re)negotiating of local understandings of place is therefore important, as is its role in sustaining narratives of resistance to locally unpopular strategic energy projects. This paper will present findings from the SEAI-funded project, EnergyPolities and cognate work, which explored how governance structures intersect with socio-economic and key socio-cultural factors to influence the social acceptability or otherwise of current energy transition pathways. It will also examine recent responses from powerful actors challenged by emerging citizen participation and engagement roles, and discusses the tactics used to limit the diversity of voices and perspectives in the energy transition.

1 Introduction

This paper reports on findings from a notable case study from the recently concluded EnergyPolities project[19], and cognate work, examining the roles and modes of citizen

[19] This project was supported by the Sustainable Energy Authority of Ireland Research, Development, and Demonstration Funding Programme under contract 18/RDD/356

participation currently taking place in the energy transition. From this research we also looked at the socio-economic and socio-cultural factors shaping participation, as well as the many intersecting experiences of citizens negotiating the governance frameworks that frame current energy transition pathways. Consequently, a key objective of the project was to identify what (in practice) constitutes ‘energy justice’ for different stakeholders. Using this approach, we hoped to develop a deeper understanding of the factors affecting the social acceptability of strategic energy projects. There has been a certain expectation in the public administration and policy domains that people’s recognition of the socio-environmental benefits of renewable energy technologies would translate into positive local responses to new energy infrastructure, especially when compared to traditional fossil fuel configurations. However, this has not been the case to date and people’s attitudes to new energy infrastructure – be it to prop up the existing fossil fuel infrastructure or newer renewable technologies – display far greater nuance and depth of understanding than is often expected of them (*e.g.*, see Koecklin *et al*., 2021). The energy transition requires us to move beyond simply swapping out one technology for another. For it to be just, it will need far greater levels of introspection and a thorough reassessment of those entrenched inequalities and power structures already locked into the current energy system (Lennon and Dunphy, 2022). Understanding how existing inequalities may replicate or even deepen as we transition will be essential if we are to respond effectively to current and future justice and ethical issues around energy. While recognising the key issues around energy are both multiscalar and intersectional will also be important to achieving the goal of a carbon neutral future.

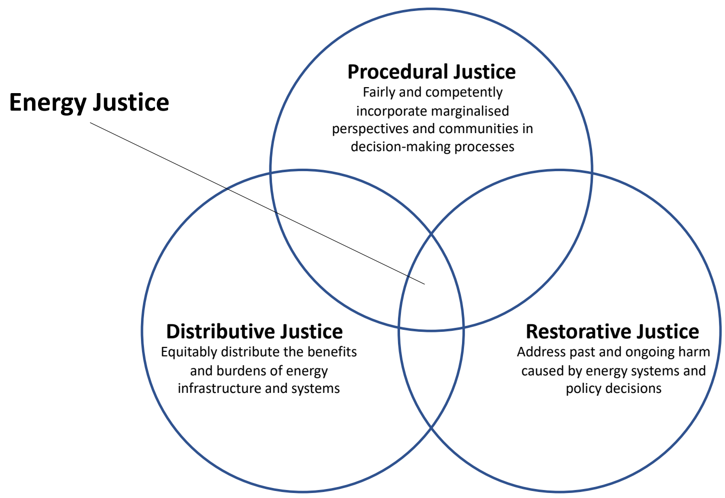

Figure 3 The three primary principles of energy justice (adapted from Wallsgrove *et al*., 2021).

An emerging critique of the policy domain that has coalesced at the interface of procedural, distributive, and restorative justice is the concept of *energy justice*, see Figure 3 above. Primarily concerned with the workings of actors at the top of the policy cycle, it seeks to apply “justice principles to energy policy, energy production and systems, energy consumption, energy activism, energy security and climate change”

(Jenkins *et al*., 2016: 174). Consequently, it has garnered considerable attention from policy makers, researchers, and even practitioners from within the energy industry itself, resulting in a certain attenuation of the concept in some circles. So much so, that some scholars suggest that while it has reached critical mass in terms of contributions in recent years, it still lacks coherency in terms of a unified conceptual framework to capture the many, sometimes competing, expressions of the concept in the literature (Lee and Byrne, 2019; Pellegrini-Masini *et al*., 2020). Fundamentally, ideas around energy justice are deeply embedded in traditional modes of philosophical and political thinking, while also incorporating substantive and formal equality concepts (*ibid.*) that now also consider the more-than-human (Sovacool *et al*., 2017; Silva Ontiveros *et al*., 2018; Jenkins *et al*., 2020; After Oil Collective, 2022). It is this multifaced aspect to the concept that in many ways makes it useful for critiquing existing governance structures and has contributed to it becoming somewhat of a guiding principle for many in energy law and policy. An *ethical turn* if you will, which may have potentially radical implications to how we realise the energy future (McHarg, 2020).

2 Spatialising justice in the energy system

Bouzarovski and Simcock (2017: 640) have broadened energy justice debates to incorporate the spatial and temporal dimensions of energy injustices across contemporary cross-sectoral energy chains. These they describe as manifesting through four key mechanisms, 1.) through landscapes of material deprivation, 2.) via geographic underpinnings of energy affordability, 3.) the lock in of vicious cycles of vulnerability, and 4.) the spaces of misrecognition. All operate along a multiplicity of scales. This spatial justice perspective is useful, not only for highlighting energy-related inequalities, but also (and possibly more importantly) for evaluating the underlying structural dynamics that go into (re)producing spatial inequalities in the energy system (*ibid*). Considering this 'spatial turn' Healy *et al*. (2019: 219) introduce the notion of *embodied energy injustices* "to encourage integrative, systemic, transboundary assessment of the global implications and responsibility of energy-policy decisions". Consequently, broadening deliberations on energy justice to also consider the often hidden, external injustices (in energy systems of the Global North at least) that are spatially distant upstream or downstream on the energy chain[20]. Understood in this way, the embodied energy injustices lens also gives decision-makers the tools to consider the broad gamut of injustice linked to individual energy policies, but also how these decisions impact on decisions made elsewhere in the policy domain. Though, as the authors acknowledge the outsourcing of injustices along the energy chain to countries in the Global South has made it more difficult to hold decision-makers to

[20] Often, it is those activities that include the extracting, processing, transporting, and the eventual disposal of energy resources and their waste streams are where some of the most egregious inequalities in the energy system take place.

account for upstream embodied injustices when they take place in another jurisdiction, state, or country.

Even in the Global North, the inherent complexities found in the policymaking ecosystems there can lead to consequences incompatible with the initial assumptions of decision-makers. For example, recent European efforts to stimulate growth in community energy projects, as part of efforts to realise a just transition to a low-carbon energy system, has been driven by presumptions that community energy in and of itself will bring about energy justice (von Bommel and Höffken, 2021). However, this assumption ignores the role existing social inequalities both frame and embed future inequalities, whether they are in society more generally or the energy chain itself. The current energy transition will neither be fair or equitable simply because we swap out one – albeit highly destructive – set of energy sources (*i.e.*, fossil fuels) for another set (*i.e.*, renewables) given much of the existing socio-technical structures that facilitate the production and consumption of oil, coal, and natural gas are now being redeployed to accommodate renewables. As von Bommel and Höffken (2021: 2) rightly point out, "not all societal groups are equally positioned to benefit from policies focused on community initiatives". This has been true for the fossil fuel economy for the past one hundred years or so, and it will be true for whatever replaces it in the future.

An interesting dimension to the energy transition that is only recently being explored are the roles and expectations being made of citizens as we transition to low carbon energy systems. In traditional fossil fuel configurations, the role expected of citizens is strictly demarcated by market sensibilities that framed energy solely as a commodity. A citizen's access to energy therefore is primarily predicated by strictly controlled purchasing arrangements as *a consumer*, with any agency clearly confined to one's purchasing ability. However, this perspective removes agency on the part of citizens to make choices beyond the prescriptive 'energy as commodity' paradigm (Lennon *et al*., 2020).

3 Public Participation in Environmental Decision-Making

In keeping with wider justice narratives, how the public is expected to coalesce around decision-making processes has shifted in recent years and range from rather proscriptive stakeholder 'engagement' processes to more participative and inclusive means of 'public/citizen participation'. The growing importance given to public participation has been attributed to several intersecting factors, including the deepening of human rights sensibilities within legal and political systems and a lowering of levels of trust in government(s) across all levels (Rauh, 2021; Dunphy *et al*., 2022). In response, a growing international interest looking to address governance concerns at both the local and national levels have manifested around a wide array participatory mechanisms (Razzaque and Richardson, 2006).

Very often, those most adversely affected by infrastructure developments in the past had little or no voice in the process. Where there were dissenting voices, these were usually side-lined via 'public consultation' events that were little more than box-ticking exercises and could be characterised as basic information sharing with any local concerns simply ignored. Increasingly, these stakeholders are beginning to experience greater transparency from project leads informed by 'people centred' or 'human-centric' principles. Areas where public participation principles have been applied include education, public policy, business, and the development sector, with tools ranging from public hearings, advocacy work, advisory/review boards, education, and information dissemination (Razzaque and Richardson, 2006).

Writing back in 1972, Lawrence Tribe acknowledged that the way decisions are made are as crucial as the decisions themselves in impacting on policy outcomes (Tribe, 1972, in Razzaque and Richardson, 2006). The same is true today. A key goal of public participation within environmental decision-making is to help decision-makers understand and effectively respond to public interest concerns in ways that are seen as fair and just. Furthermore, as public participation within the decision-making process encourages accountability of final decisions – which in turn informs acceptability – this can potentially lead to fewer project delays, less litigation *etc*., and should understandably serve as a motivating factor for those hoping to move forward with a planned development (Razzaque and Richardson, 2006, in Dunphy *et al*., 2022). However, much of the mixed results we continue to see around public engagement can be explained by confusion or a certain unwillingness on the part of project leads to move away from unproductive 'consultation' methods (box-ticking exercises like information meetings *etc*., usually held by hired public relations firms with little or no real knowledge of local issues) to more inclusive, participatory approaches that require more time and resources (Dwyer, 2016; ten Brink and Dalton, 2018).

3.1 Public Participation in Energy Infrastructure Projects

Discussions on public participation very often settle on Sherry Arnstein's seminal 1969 'ladder of citizen participation', which continues to inform scholars on how to involve citizens in decision making processes. In it, she outlines participation as occupying a spectrum of different engagement and participation potentials, ranging from notification at the bottom rung (effectively, non-participation) to joint decision-making power – including the ability to veto proposed decisions – at the top rung (Arnstein, 1969). The distinction between "top-down" and "bottom-up" approaches to participation has also been made, with communications by governments occupying the former example, and community-led initiatives occupying the latter (Langton, 1978, in Razzaque and Richardson, 2006). Participation has been described using other models that incorporate substantive or procedural involvement, however the two distinctions are often confused or misapplied in practice (Ebbesson, 1992, in Razzaque and Richardson, 2006).

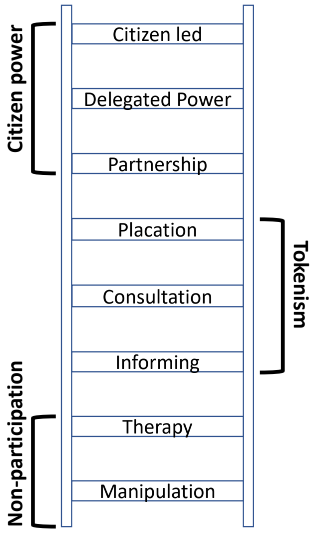

Figure 4 Ladder of participation (adapted from Arnstein, 1969).

Looking at the literature on public engagement – most notably engagement with energy infrastructure projects – there are distinctions between discourses on ‘public participation’ and ‘public acceptance’, both of which recognise the importance of citizen engagement with the project process. However, despite shared commonalities at first glance, they are fundamentally different in how the roles and expectations of engagement are ultimately understood (Armeni, 2016). In participatory public engagement approaches it is assumed that a variety of options are still on the table and open for debate, and therefore influence. Consequently, it is taken as given the public has real (as opposed to tokenistic) capacity to impact the decision-making process. This approach seeks to achieve inclusive more transparent decision-making by involving people in deliberative, consensus-based public consultations (*ibid*.). In contrast, public acceptance models invariably view public engagement/participation with the project as more of a bureaucratic hurdle to be overcome so the project can advance. It is seen as a means for increasing social support for a project and validating decisions that have already been made. In this context acceptance is a means to accelerate the implementation of a project, where alternative options for discussion have already been taken off the table (*ibid*.).

One should also note that public concerns or opposition to a project may not necessarily be ameliorated by the existence of legal and enforceable rights to participate in the decision-making process. Very often, wider legal and policy contexts tend to negate the public’s ability to impact decision-making through the use of ‘expert knowledge’ the challenge and/or discredit genuine public concerns. These are commonly put forward as part of risk assessment paradigms, cost-benefit analyses, and deficit models, and tend to mislead the public about the level of influence they actually have over the decision-making process. In emphasising citizens' procedural rights to participate, such models tend to encourage public engagement only in terms of transparency and accountability, often portraying the public concerns as irrational, emotional, or scientifically ignorant (*ibid*.). This 'decide-announce-defend' approach, adopted by many developers, ignores the genuine concerns of local people and consequently has garnered considerable attention in the literature (Natarajan *et al.,* 2018).

4 Research Design and Methodology

The research presented in this paper set out to unpack and analyse the many intersecting roles and expectations made on citizens in three case study communities, two in Ireland and one in Austria. This paper focuses on one of the case study communities, the Corrib Gas pipeline dispute in County Mayo, Ireland. This section briefly outlines the approach taken to meet the complex challenges presented to the researchers and the methodological approach deployed to meet those challenges.
The methodology followed the form of 'engaged research' (Holliman et al., 2015), representing a range of methodological approaches that strive to co-produce relevant and meaningful research by engaging academic researchers with members of non-academic arenas (*e.g.*, stakeholders, end-users, and/or members of the public). An engaged research approach is very useful when undertaking an intersectional analysis of citizen participation. However, the emergence of the COVID-19 pandemic significantly impacted initial efforts to undertake the types of engaged research usually deployed for a study of this kind. In response, the research team adapted to the changing protocols around engagement, conducting an extensive search and review of the literature, complementing the in-depth semi-structured interviews with informants in each case study. When in-person interviews were not feasible, the research team pivoted to using video-conferencing platforms made more ubiquitous by the pandemic. Every effort was made to engage informants representing a diversity of perspectives and the resultant interview notes were then analysed using thematic analysis to identify, analyse, and interpret patterns of meaning emerging from the discussions. The following sections provide an overview of the methods used in the study, namely: in-depth interviews and thematic analysis.

4.1 Semi-structured interviews

To complement the literature review and allow for an in-depth analysis of citizen perspective on participation, key informants were engaged through semi-structured interviews. Described as a 'conversation with a purpose' (Webb & Webb, 1936, quoted in Legard *et al*., 2003, p138) an interview requires significant preparation in advance and the aim is to gain an appreciation of the perspective of interviewees about a given topic. Dunphy *et al*., (2021) note allowing for sufficient time and scope in the

engagement for the interviewee to feel able to give their point of view and to tell 'their story'.
Participants in the semi-interviews comprised key actors involved in each of citizen mobilisations examined by the project. For the case study at the centre of this paper, the Corrib Gas pipeline dispute, informal interviews were conducted not only with the protesters but with actors in the community development sector in Mayo. Also, local people not immediately connected to the protests, but who had knowledge of events arising from the protests or knew people associated with those events, were also consulted. The interviews carried out in-person prior to the COVID-19 crisis, and via video-conferencing thereafter, used pre-formed interview schedules of concise, clear, and open-ended questions. Applying Dunphy *et al*.'s (2021) approach, the prompts and probes where specifically designed to examine the roles and expectations made on citizens – along with their perceptions of those expectations – as participants in the energy system. During the interview, extensive notes were taken, including any relevant non-verbal communication, which proved possible in videoconferencing. The video-calls were recorded where permission was provided, and these recordings were used to supplement and enhance the notes, which were then analysed as described in the next section.

4.2 Data analysis and interpretation

Interpreting the interview notes involved a comprehensive qualitative analysis to study what was communicated and theorise from those findings (Schwandt, 2007). This iterative approach, returning time and again to the data, was often time-consuming and painstaking work. As indicated by Dunphy *et al*., (2021) the analysis began with an initial read-through of the notes taken[21]. Following on from this, the texts were then carefully analysed to capture key information and to identify themes most relevant to examining the drivers and barriers to public participation in energy. Subsequently, emergent data was then cross-referenced and linked to that from the literature review. In this way, any inconsistencies were resolved by filling in identified knowledge gaps and the iterative process ensured any fresh inconsistencies were also resolved. Next, the notes were thematically analysed involving the systematic ordering, categorising, and labelling of text. Given the relatively small dataset, it was possible to code the text by hand and significantly reduce the iterative analysis and interpretation process.

5. Place identity and perceptions of trust

Understanding the modes of citizen participation was therefore a key area of interest for the EnergyPolities project, particularly in terms of civic mobilisation around energy projects. For this paper, a key aspect to citizen mobilisation we examined concerns the

[21] This read-through process was repeated until the material became familiar to the analyst.

role place has as a motivating factor for people. The case study in question looked at protests around the construction of a natural gas pipeline and onshore terminal near the village of Rossport, in Co Mayo, in the West of Ireland during the late 1990s and 2000s. Much of the campaign material generated around the protests situated ideas of place as central to the narrative identities of many of the protesters. This is noteworthy, since place is not simply just a physical site, a 'surface' or points or areas on a map. Instead, place is imbued with meaning and better understood as an "integration of space and time" (Massey, 2005: 130). In order words, instead of understanding place as 'a thing', more accurately it can be described as a manifestation of spatio-temporal events, or a confluence of "stories-so-far" (*ibid.*). Place is something one interprets, moves to, or indeed moves through. It defines and is redefined through experiences, and it is through these contexts that place is both formed and contested.

> If space is rather a simultaneity of stories-so-far, then places are collections of those stories, articulations within the wider power-geometries of space
> (Doreen Massey, 2005: 130)

With regards to the energy transition, place and the idea of place has often been used to express and contextualise local discord, and to present alternative counter-narratives to official (and therefore sanctioned) perspectives. This approach has been used from everything from protesting energy infrastructure and road projects to environmental protection legislation *etc*. As Peng *et al*. (2020: 14) suggest, people's identification with a place and the place identity of that same place overlap. They are not the same thing, but rather both constructs "embody subjective or emotional bonds" between humans and the physical world and it is important to understand that *place identity* forms part of an individual's personality. The role of place is key to the formation of individual identities, with place identity contributing to the overall personality of a place (*ibid*).

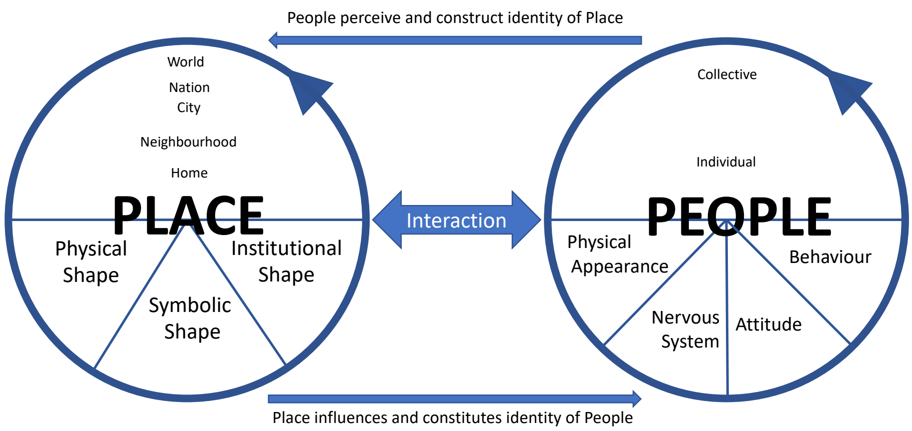

Figure 5 The interconnecting relationships between people, place, and place identity (adapted from Peng *et al*., 2020: 15).

Therefore, it is this integration of physical reality and social cognition that sees considerable overlap with environmental psychological concepts such as place attachment. All have a role in contextualising and framing the causal factors affecting disputes as they arise from local place development, planning, and social conflicts. In conjunction with the spatial dimension, one must also consider temporal factors. Just because a project was successfully built in an area does not mean the next project will meet with the same level of 'acceptance' from local people. As such places,

> …do not necessarily exhibit particular qualities or have predetermined effects in the world. In this sense, like practices, places are entities that are constantly changing
>
> (Pink, 2012: 24)

5.1 Public perceptions of place and trust when negotiating acceptability

Public perceptions about climate change must always be factored in when introducing specific energy technologies to debates on how best to tackle it and related issues (Nisbet, 2009; Corner *et al.,* 2014). For example, any energy development must now invariably be linked to public concerns around climate change, with perceptions of the technology (whether fossil fuel or renewable) contributing to public expectations of its mitigating effectiveness on climate or otherwise. This is an important factor that is often ignored by project leads when trying to influence public acceptance (Sharp *et al.,* 2009), or when it is addressed, it is often used to justify what might otherwise be seen as a locally unjust project. In this scenario, those who accept the science on climate change will have specific understandings of the impact an energy project may have on wider mitigation strategies. In the case of oil, coal, and natural gas, those who understand the science are less likely to be predisposed to further exploitation of such energy sources given their negative impact on global climate temperatures (Davis *et al.,* 2010; Grasso, 2019; Howarth, 2014; Jackson *et al.,* 2019; Poortinga *et al.,* 2018). These understandings feed into the contextual and psychological components that shape community and individual cost /benefit perceptions. Perlaviciute and Steg (2014), for example, outline the factors that impact people's judgement and in turn acceptability of energy technologies and their alternatives. Their conceptual framework acknowledges how contextual and general psychological factors have been addressed, namely as independent predictors. However, the contextual and general psychological factors intersect with each other when "shaping evaluations and acceptability of energy alternatives and should therefore be studied in combination" (*ibid.*, 2014: 363). Therefore, place attachment should also be seen as a multidimensional concept with personal, psychological process, and place dimensions to consider.

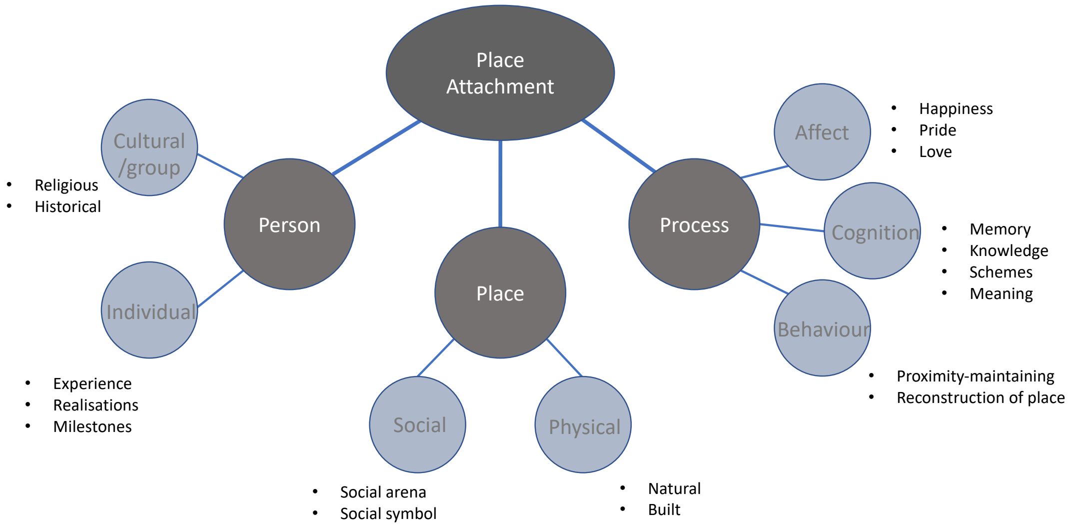

Figure 6 Conceptual framework outlining how evaluation and acceptability are determined by multiple, intersecting criteria that shape an individual's perception of a specific (energy) project as it relates to place (adapted from Perlaviciute and Steg, 2014: 363).

Perlaviciute and Steg conclude that renewable energy sources (RES) are generally viewed as clean, safe, and possessing a lower environmental impact than say fossil fuels. As a result, the attributed higher collective benefit and lower collective costs for society can be more easily understood (Culley *et al.,* 2011; Butler *et al.,* 2013; Parkhill *et al.,* 2013). However, there are caveats to this and often it can very much depend on the RES technology involved, *e.g.*, wind and solar power are frequently seen more favourably, while other RES technologies like bioenergy may (sometimes incorrectly) be linked to fossil fuels and therefore not be considered a viable energy source (Butler et al., 2013). Contextual variables (energy pricing, operational safety, *etc.*) also impact on public perceptions with individual costs and related advantages thus influencing societal acceptability of RES technology in particular (Perlaviciute and Steg, 2014). In addition, the associated costs and benefits of a particular technology may be perceived differently depending on individual circumstance. Therefore, different levels of acceptability will be reported despite individuals accessing for example the same information on a specific energy technology. Research on the psychological factors influencing how the public evaluates energy technologies also points to a number of key aspects, including place-attachment and identity, predictability, individual values and trust (Lindenberg and Steg, 2007).

Place-attachment and place-identity have received growing attention in the literature in recent years as alternative means for explaining people's judgement, and consequently acceptance, of energy technologies. Often, they are seen as somewhat of a counterpoint to reductive and accusatory NIMBYist explanations for local resistances/mobilisations to specific energy projects (Vorkinn and Riese, 2001; Devine-Wright, 2005, 2009, 2011; Devine-Wright and Howes, 2010). Place attachment and identity, respectively, relate to one's emotional attachment to a local place, and the level to which it contributes to an individual's sense of self (Vorkinn and Riese, 2001; Devine-Wright, 2005, 2009). Where an energy project is seen to threaten these characteristics (Devine-Wright, 2009) unfavourable attitudes may develop in response to that development (Vorkinn and Riese, 2001). Alternatively, some stakeholders – depending on the circumstances – may perceive the same energy project as being more beneficial to the community (Devine-Wright, 2011; Butler *et al*., 2013). In addition, the level of trust for the developers leading the project is equally important and plays a significant role in influencing the public's perception of whether a specific development threatens their neighbourhood or not. For example, the Corrib Gas dispute reflects a case in the United Kingdom that Devine-Wright and Howes (2010) highlight where place-attachment and its impact on local identity there had a significant negative impact on local levels of acceptance towards of a proposed large-scale offshore wind farm. This was further compounded by a lack of trust by many locals regarding the true intentions of the developer leading that project (Devine-Wright and Howes, 2010). In essence, both place attachment and trust acted as drivers, each informing the other, and in turn strengthening the positive/negative (in both cases negative) response to the project.

As Perlaviciute and Steg (2014) suggest, individual values may also account for the varying levels of trust, place-attachment, and identity that inform people's overall acceptance of energy technology projects in their area. Values may be determined by ideals that constitute what is important to the individual and can encompass the psychological elements influencing a variety of attitudes, beliefs, preferences, and behaviours (Schwartz, 1992; Rohan, 2000; Schultz, 2001; Maio, 2010; Steg *et al*., 2011). Therefore, it is no surprise that there has been considerable research into the role *values* play in determining public acceptance of energy technologies (Whitfield *et al*., 2009; de Groot and Steg, 2011; Bidwell, 2013; Butler *et al*., 2013; de Groot, Steg and Poortinga, 2013; Parkhill *et al.,* 2013). Of note, are the distinctions made between self-transcendence and self-enhancement values (Stern *et al.,* 1998; Stern, 2000; Nordlund and Garvill, 2002; Dietz, Fitzgerald, and Shwom, 2005; de Groot and Steg, 2008; Steg and de Groot, 2012; Phillips *et al*., 2019), with the former concerned with collective outcomes while the latter focusses on the costs and benefits at the individual level. For instance, when holding self-transcendence values, one may consider the collective outcome of a given project and express a combination of altruistic values (focusing on the well-being of others) and biospheric values relating to strong environmental self-identity (Wang *et al.,* 2021). Alternatively, one may hold stronger egoistic values, incorporating safe-guarding and self-preservation tendencies in the pursuit of enhancing one's own resources (*e.g.*, wealth, status, *etc.*), or focus on following hedonic values devoted to improving how one feels (*e.g.*, comfort, pleasure, *etc.*), which comprise what are referred to as self-enhancement values (Perlaviciute and Steg, 2014). Individual values can and do determine the social acceptability of various energy technologies, with those possessing higher altruistic and/or biospheric values being more likely to support and accept energy alternatives that offer higher collective benefits and low collective costs. While those with higher egoistic and/or hedonic values show a greater likelihood for accepting technologies that offer high perceived individual benefits and low perceived costs. In this regard self-transcendence values have been shown to lead to more positive attitudes towards renewable energy technologies and greater social acceptance (Bang *et al.,* 2000; Arkesteijn and Oerlemans, 2005; Spence *et al.,* 2010).

6 Discussion: the role of place in the case study communities

Consequently, a particular landscape can be seen both as a suitable site for practicing good climate governance, while simultaneously the very same space can be held up as an exemplar natural environment in need of protection from 21st Century-style industrialisation. Indeed, for some, renewables (just like the fossil fuels they are designed to replace) render the landscape just as symptomatic of wider societal inequalities and the exploitation of the natural environment. As Ellis *et al.* put it,

> the key issues facing wind farm [RES] development are not "objective" policy blockages, but clashes of values related to inter alia, governance, technology, landscape aesthetics, issues of participation and power inequalities.
>
> (Ellis *et al.,* 2007: 524)

Therefore, when it comes to energy, place is a defining issue. Given the strategic value of energy production, the decision to situate new energy infrastructure is usually determined through the spatial planning process. With local authorities or national planning bodies [in Ireland, An Bord Pleanála] being responsible, depending on the size of the proposed project, it is often during the planning process that multiple perspectives of place get to intersect with the values and perspectives of the different actors involved.

For the protesters we spoke to in relation to the Corrib Gas pipeline, it was striking how much the sense of place featured in their discussions. One respondent described a conversation he had with a couple of prominent leaders of the protests where he asked them what the protests were all about and they summed up their involvement to him as follows, essentially "…this is all about memories, the footsteps, our footsteps are around this property, we grew up here" (CG2). A self-declared motivating factor was the individual and familial histories that intertwine with the physical landscape to inform local perceptions of place. As Stephanie Taylor (2010) suggests, the place where people live their lives still plays an important role in their identity, especially within the narratives they use to express who they are. And while a "person's identity ('who I am') is fragmented and unfixed, differing, for example, from one situation to another" (*ibid.*, 2010: 43) – this can be seen as a process of ongoing, open-ended change – notions of place still act as an anchor for many people's *identity work*. A notable example of this is the name local people assign to the area around the Corrib Gas pipeline, which links back to the medieval Norman baronies rather than the more modern county system used today in Ireland:

> Like you have to understand Erris. You have to understand it as a [pause] it's a very unique area in Ireland because it's probably the only place I know that still identifies itself as a barony. Baronies are Norman and again this is interesting geographically, baronies are old Norman divisions, and they predate counties, and they are deeper than counties. I doubt anybody in Ireland knows what barony they live in. It's a completely redundant idea and in Mayo no-one knows what barony they live in, but Erris people do. Erris is the only place that is distinctive by virtue of its barony. And so, people talk about 'Erris' and it means something.
>
> (CG2)

It was also a strong factor in defining how local people responded to the pipeline. One respondent described this as an *indigenous sense of place*, where belonging is wrapped up within oneself but also with one's familial history and "the integrity of a place not being disturbed" (CG2) by external actors. It is, therefore, this maelstrom of place attachment, identity work, and personal values that continues to shape one's understanding of place and is in turn shaped by the collective and personal interpretations a potential energy project might have on those constructions.

In turn, these contestations of place and place identities reveal (in part at least) the many power imbalances different actors experience in strategic energy infrastructure projects. Identities are ascribed to a place by social actors who have different knowledges, interests, and/or power relations to that place (Peng *et al.,* 2020). As Doreen Massey (2005: 85) puts it, "not only is space utterly imbued with and a product of relations of power, but power itself has a geography. There are cartographies of power." How these are expressed, reflects the power one has within one's own social group, but also in relation to those wider social groups external to one's locality.

For both case studies, place identity was constantly being reaffirmed, built upon, and applied amongst the protesters in order to strengthen bonds within the movement and for (re)establishing core identities whenever the local leaders of the protests were in danger of being subsumed within wider national protest networks. The use of protest camps in Erris, ensured that the focus of the protests remained close to where the pipeline was. It remained the site for contestation. This also ensured those leading the protests retained control over the direction the protests were to take, even when they began to attract more national and international attention. As such, place continues to hold significant symbolic and representative meaning through the intersecting interpretations of space, power, and identity for stakeholders across the energy domain.

7 Conclusion

This paper reports on findings from recent research into the roles and modes of citizen participation currently taking place in the energy transition. Most notably, we focused on how ideas of ‘energy justice’ are framed by local stakeholders’ perceptions of trust, place-attachment, and personal identity when mobilising in response to a strategic energy project in their area. Our work was very much informed by Doreen Massey’s (2005) understanding of the ‘power-geometries of space’ and Peng et al.’s (2020) work on the interconnecting relationships between people, place, and place identity. From these and other contributions from the literature, we were able to frame our own study using Perlaviciute and Steg’s (2014) conceptual framework for outlining how evaluation and acceptability are determined by multiple, intersecting criteria in shaping an individual’s perception of a specific (energy) project. Taken together, we were able to examine in-depth the perceptions of citizens in each of the three case studies comprising the EnergyPolities project. From our analysis, place played a significant role in framing not only the narratives for resisting specific (energy) projects but also the personal identities of many of the protesters involved.

However, as Sayan (2019: 3) suggests “place-based approaches remain a niche area of research which have not been adequately considered directly within the conceptual framework of energy justice”. This is surprising given the intersecting relational impacts experienced by policy, the environment and the local communities affected by energy production and applies to renewable energy just as much as to the carbon-based sources it replaces. This paper seeks to contribute to furthering place-based studies in energy research. If we are to have a just and equitable energy transition, place and an acknowledgement of specific, local place identities, will need to occupy a more central role in energy planning and associated projects over the coming decades.

8 References

After Oil Collective. (2022). Solarities: Seeking Energy Justice (A. Vemuri & D. Barney, eds.). University of Minnesota Press. https://www.upress.umn.edu/book-division/books/solarities

Anderson, J. and Douglas, J. (2005) Promoting Civic Engagement at the University of California: Recommendations from the Strategy Group on Civic and Academic Engagement [online]. Available at: https://gspp.berkeley.edu/faculty-and-impact/publications/report-promoting-civic-engagement-at-the-university-of-california-recommend (accessed 23 August 2022)

Bouzarovski, S., & Simcock, N. (2017). Spatializing energy justice. Energy Policy, 107. https://doi.org/10.1016/j.enpol.2017.03.064

Butler, C., Parkhill, K. A. and Pidgeon, N. (2013) Deliberating Energy System Transitions in the UK - Transforming the UK Energy System: Public Values, Attitudes and Acceptability, UK Energy Research Centre. London.

Corner, A., Markowitz, E. and Pidgeon, N. (2014) 'Public engagement with climate change: The role of human values', Wiley Interdisciplinary Reviews: Climate Change, 5(3), pp. 411–422. https://doi.org/10.1002/wcc.269.

Culley, M. R. et al. (2011) 'Sun, Wind, Rock and Metal: Attitudes toward Renewable and Non-renewable Energy Sources in the Context of Climate Change and Current Energy Debates', Current Psychology, 30(3), pp. 215–233. https://doi.org/10.1007/s12144-011-9110-5.

Davis, S. J., Caldeira, K., & Matthews, H. D. (2010). Future CO2 Emissions and Climate Change from Existing Energy Infrastructure. Science, 329(5997), 1330–1333. https://doi.org/10.1126/science.1188566

Devine-Wright, P. (2005) 'Beyond NIMBYism: towards an integrated framework for understanding public perceptions of wind energy', Wind Energy, 8(2), pp. 125–139. https://doi.org/10.1002/we.124.

Devine-Wright, P. (2009) 'Rethinking NIMBYism: The role of place attachment and place identity in explaining place-protective action', Journal of Community & Applied Social Psychology, 19(6), pp. 426–441. https://doi.org/10.1002/casp.1004.

Devine-Wright, P. (2011) 'Place attachment and public acceptance of renewable energy: A tidal energy case study', Journal of Environmental Psychology. Elsevier Ltd, 31(4), pp. 336–343. https://doi.org/10.1016/j.jenvp.2011.07.001.

Devine-Wright, P. and Howes, Y. (2010) 'Disruption to place attachment and the protection of restorative environments: A wind energy case study', Journal of Environmental Psychology. Elsevier Ltd, 30(3), pp. 271–280. https://doi.org/10.1016/j.jenvp.2010.01.008.

Dietz, T., Fitzgerald, A. and Shwom, R. (2005) 'Environmental Values', Annual Review of Environment and Resources, 30(1), pp. 335–372. https://doi.org/10.1146/annurev.energy.30.050504.144444.

Dunphy, N.P., Lennon, B., Quinlivan, L., Velasco-Herrejón, P., and Curran, R. (2021). Critical review of education and public engagement initiatives. Deliverable 4.1 of the REALISE H2020 project, funded under the EU Horizon 2020 research and innovation programme under grant agreement No 884266.

Dunphy, N. P., Lennon, B., Quinlivan, L., & Velasco-Herrejón, P. (2022) Framework of social acceptability factors of energy projects. Deliverable WP4-D2 of the EnergyPolities project, SEAI, Ireland.

Grasso, M. (2019). Oily politics: A critical assessment of the oil and gas industry’s contribution to climate change. Energy Research & Social Science, 50, 106–115. https://doi.org/10.1016/j.erss.2018.11.017

Healy, N., Stephens, J. C., & Malin, S. A. (2019). Embodied energy injustices: Unveiling and politicizing the transboundary harms of fossil fuel extractivism and fossil fuel supply chains. Energy Research & Social Science, 48, 219–234. https://doi.org/10.1016/j.erss.2018.09.016

Howarth, R. W. (2014). A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas. Energy Science & Engineering, 2(2), 47–60. https://doi.org/10.1002/ese3.35

Jackson, R. B., Friedlingstein, P., Andrew, R. M., Canadell, J. G., le Quéré, C., & Peters, G. P. (2019). Persistent fossil fuel growth threatens the Paris Agreement and planetary health. Environmental Research Letters, 14(12), 121001. https://doi.org/10.1088/1748-9326/ab57b3

Jenkins, K. E. H., Spruit, S., Milchram, C., Höffken, J., & Taebi, B. (2020). Synthesizing value sensitive design, responsible research and innovation, and energy justice: A conceptual review. Energy Research & Social Science, 69, 101727. https://doi.org/10.1016/j.erss.2020.101727

Jenkins, K., McCauley, D., Heffron, R., Stephan, H., & Rehner, R. (2016). Energy justice: A conceptual review. Energy Research & Social Science, 11, 174–182. https://doi.org/10.1016/j.erss.2015.10.004

Koecklin, M. T., Longoria, G., Fitiwi, D. Z., DeCarolis, J. F., & Curtis, J. (2021). Public acceptance of renewable electricity generation and transmission network developments: Insights from Ireland. Energy Policy, 151, 112185. https://doi.org/10.1016/j.enpol.2021.112185

Lee, J., & Byrne, J. (2019). Expanding the Conceptual and Analytical Basis of Energy Justice: Beyond the Three-Tenet Framework. Frontiers in Energy Research, 7. https://doi.org/10.3389/fenrg.2019.00099

Legard, R., Keegan, J. and Ward, K. (2003) In-depth Interviews. In J. Richie & J. Lewis (eds.) Qualitative Research Practice: A Guide for Social Science Students and Researchers (pp. 138–169). SAGE Publications.

Lennon, B. & Dunphy, N.P. (2022) Mind the gap: citizens, consumers and unequal participation in global energy transitions. In (eds.) Nadesan, M.H., Pasqualetti, M.J. and Keahey, J., Energy Democracies for Sustainable Futures. Elsevier.

Lennon, B., Dunphy, N. P., Gaffney, C., Revez, A., Mullally, G., and O’Connor, P. (2020) Citizen or Consumer? Reconsidering Energy Citizenship. Journal of

Environmental Policy and Planning, 22 (2): 184-197. https://doi.org/10.1080/1523908X.2019.1680277

Lindenberg, S. and Steg, L. (2007) ‘Normative, Gain and Hedonic Goal Frames Guiding Environmental Behavior’, Journal of Social Issues, 63(1), pp. 117–137. https://doi.org/10.1111/j.1540-4560.2007.00499.x.

Massey, D. (2005) For Space. London: Sage Publications.

McHarg, A. (2020). Energy Justice. In Energy Justice and Energy Law (pp. 15–30). Oxford University Press. https://doi.org/10.1093/oso/9780198860754.003.0002

Morgan, David L.; Bottorff, Joan L. (2010): Advancing Our Craft: Focus Group Methods and Practice. In Qual Health Res 20 (5), pp. 579–581. DOI: 10.1177/1049732310364625.

Nielsen-Bohlman, Lynn; Panzer, Allison M.; Kindig, David A.; Institute of Medicine, Committee on Health Literacy (Eds.) (2004): Health literacy. A prescription to end confusion.

Nisbet, M. C. (2009) ‘Communicating Climate Change: Why Frames Matter for Public Engagement’, Environment: Science and Policy for Sustainable Development, 51(2), pp. 12–23. https://doi.org/10.3200/ENVT.51.2.12-23.

Nordlund, A. M. and Garvill, J. (2002) ‘Value Structures behind Proenvironmental Behavior’, Environment and Behavior, 34(6), pp. 740–756. https://doi.org/10.1177/001391602237244.

Parkhill, K., Demski, C., Butler, C., Spence, A. and Pidgeon, N. (2013) Transforming the UK Energy System: Public Values, Attitudes and Acceptability - Synthesis Report. UK Energy Research Centre: London. https://eprints.whiterose.ac.uk/82906/.

Peng J., Strijker, D. and Wu, Q. (2020) Place Identity: How Far Have We Come in Exploring Its Meanings? Frontiers in Psychology. 11:294. https://doi.org/10.3389/fpsyg.2020.00294.

Perlaviciute, G. and Steg, L. (2014) Contextual and psychological factors shaping evaluations and acceptability of energy alternatives: Integrated review and research agenda. Renewable and Sustainable Energy Reviews. Elsevier, 35, pp. 361–381. https://doi.org/10.1016/j.rser.2014.04.003.

Pink, S. (2012) Situating Everyday Life: Practices and Places. London & Thousand Oaks: Sage Publications.

Poortinga, W., Fisher, S., Böhm, G., Steg, L., Whitmarsh, L., & Ogunbode, C. (2018). European Attitudes to Climate Change and Energy: Topline Results from Round 8 of the European Social Survey. Online: https://bit.ly/3z443U2

Razzaque, J., & Richardson, B. (2006). Public participation in environmental decision-making. In B. Richardson, & S. Wood (Eds.), Environmental Law for Sustainability, 165-194. Hart Publishing.

Rauh, J. (2021). Is trust in government really declining? Evidence using the sequential probability ratio test. Acta Politica, 56(3), 500–529. https://doi.org/10.1057/s41269-020-00163-7

Rohan, M. J. (2000) A Rose by Any Name? The Values Construct. Personality and Social Psychology Review, 4(3), pp. 255–277. https://doi.org/10.1207/S15327957PSPR0403_4

Sayan, R. C. (2019). Exploring place-based approaches and energy justice: Ecology, social movements, and hydropower in Turkey. Energy Research & Social Science, 57, 101234. https://doi.org/10.1016/j.erss.2019.101234

Schultz, P. (2001) The Structure of Environmental Concern: Concern For Self, Other People, And The Biosphere. Journal of Environmental Psychology, 21(4), pp. 327–339. https://doi.org/10.1006/jevp.2001.0227

Schwandt, T.A. (2007). The Sage Dictionary of Qualitative Inquiry (3rd ed.). Sage Publications, Inc. https://dx.doi.org/10.4135/9781412986281

Schwartz, S. H. (1992) 'Universals in the Content and Structure of Values: Theoretical Advances and Empirical Tests in 20 Countries', in Advances in Experimental Social Psychology, pp. 1–65. https://doi.org/10.1016/S0065-2601(08)60281-6.

Sharp, J. D., Jaccard, M. K. and Keith, D. W. (2009) 'Anticipating public attitudes toward underground CO2 storage', International Journal of Greenhouse Gas Control, 3(5), pp. 641–651. https://doi.org/10.1016/j.ijggc.2009.04.001

Silva Ontiveros, L., Munro, P. G., & Melo Zurita, M. de L. (2018). Proyectos de Muerte: Energy justice conflicts on Mexico's unconventional gas frontier. The Extractive Industries and Society, 5(4), 481–489. https://doi.org/10.1016/j.exis.2018.06.010

Sovacool, B. K., Burke, M., Baker, L., Kotikalapudi, C. K., & Wlokas, H. (2017). New frontiers and conceptual frameworks for energy justice. Energy Policy, 105(March), 677–691. https://doi.org/10.1016/j.enpol.2017.03.005

Stern, P. C. (2000) 'Toward a Coherent Theory of Environmentally Significant Behavior', Journal of Social Issues, 56(3), pp. 407–424. https://doi.org/10.1111/0022-4537.00175

Stern, P. C., Dietz, T. and Guagnano, G. A. (1998) 'A Brief Inventory of Values', Educational and Psychological Measurement, 58(6), pp. 984–1001. https://doi.org/10.1177/0013164498058006008 ten Brink TS and Dalton T (2018) Perceptions of Commercial and Recreational Fishers on the Potential Ecological Impacts of the Block Island Wind Farm (US). Frontiers in Marine Science. 5:439. https://doi.org/10.3389/fmars.2018.00439

van Bommel, N., & Höffken, J. I. (2021). Energy justice within, between and beyond European community energy initiatives: A review. Energy Research & Social Science, 79, 102157. https://doi.org/10.1016/j.erss.2021.102157

Vorkinn, M. and Riese, H. (2001) 'Environmental Concern in a Local Context', Environment and Behavior, 33(2), pp. 249–263. https://doi.org/10.1177/00139160121972972

Wallsgrove, R., Woo, J., Lee, J.-H., & Akiba, L. (2021). The Emerging Potential of Microgrids in the Transition to 100% Renewable Energy Systems. Energies, 14(6), 1687. https://doi.org/10.3390/en14061687

Wang, X. and Van Wart, M. (2007) 'When Public Participation in Administration Leads to Trust: An Empirical Assessment of Managers' Perceptions', Public Administration Review, pp. 265–278. https://doi.org/10.1111/j.1540-6210.2007.00712.x

Wang, X., van der Werff, E., Bouman, T., Harder, M. K., & Steg, L. (2021). I Am vs. We Are: How Biospheric Values and Environmental Identity of Individuals and Groups Can Influence Pro-environmental Behaviour. Frontiers in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.618956

Whitfield, S. C., Rosa, E. A., Dan, A. & Dietz, T. (2009) The Future of Nuclear Power: Value Orientations and Risk Perception. Risk Analysis, 29(3), pp. 425–437. https://doi.org/10.1111/j.1539-6924.2008.01155.x

Wüstenhagen, R., Wolsink, M. and Bürer, M. J. (2007) 'Social acceptance of renewable energy innovation: An introduction to the concept', Energy Policy, 35(5), pp. 2683–2691. https://doi.org/10.1016/j.enpol.2006.12.001

Opportunities of responsible innovation approach in the spread of AV technology

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Abstract. Although the vast majority of research related to autonomous vehicles (AV) is of technological and natural scientific nature, more and more social scientific research is being conducted in this topic. These works frequently draw attention to the wide range of uncertainties and open questions regarding AVs. It offers an excellent opportunity to approach social challenges concerning AVs through the conceptual system of responsible innovation (RI). Understanding the complex relationship of society and AV technology becomes much more significant to handle the uncertainties and ethical challenges of AVs.
In the light of the above, our theoretical research focuses on literature review, in which we address how responsible innovation framework can contribute to the most socially desirable outcome concerning Avs. The long-term objective of our research is to lay the foundation of a socio-technical integration which maximizes the advantages and minimizes the disadvantages of autonomous technology.
The examination of the relationship between RI and AV technology revealed several facts which suggest that the application of RI is justified. The literature highlighted that public engagement should be realised in a special socio-technical integration which is embedded in the framework of RI, thus it is important to involve the widest possible range of society in innovation processes[22].

Keywords: socio-technical integration, responsible innovation, emerging technologies, autonomous vehicles

1 Introduction

The question is no longer whether all road vehicles become completely autonomous but rather when (Grindsted et al. 2022, Threlfall 2018). Some authors draw attention to the traffic reducing advantages of AVs suggesting that sharing-based AV fleets will be able to move the same amount of traffic with using fewer vehicles compared to

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privately owned vehicles (Liljamo et al. 2021, Kesselring et al. 2020, Spurling - McMeekin 2014, Fagnant - Kockelman 2016, Alazzawi et al. 2018, Martinez - Viegas 2017, Overtoom et al. 2020). Other authors consider that a part of the advantages can be of economic and social nature (Threlfall 2018, Lipson - Kurman 2016, Litman 2017, Bezai et al. 2021): the hours spent driving can be transformed into productive time, the number of road accidents caused by human error can be reduced, safety and convenience can increase, environmental pollution and fuel consumption can decrease, and the mobility of disabled and elderly people can become easier (Litman 2017, Bezai et al. 2021). Combs et al. (2019) included the analysis of pedestrian fatalities in the United States and assessed the cases where tragic outcomes could have been avoided if AVs equipped with pedestrian warning systems had been used. The study showed that out of 4241 traffic-related fatal cases of pedestrian accidents, 3386 could have been avoided, which represents roughly 80% decrease in fatality rate. However, numerous challenges and concerns can be connected to AVs (Threlfall 2018, Bezai et al. 2021). For example, the transport system can become vulnerable to hacker attacks through digitalisation (Alfonso et al. 2018, Atzori et al. 2018). Another threat linked to AVs is the malicious cyber-attacks through an unreliable network (Kim 2018). Besides, the use of two modes of driving (manual and automated) may lead to unclear communication, which could lead to accidents (Straub Schaefer 2019). The acceptance and attitude of users can also represent an obstacle in the application of AV technology (Liljamo et al. 2018, Bezai et al. 2021).
This brings up an important question about how to handle the uncertainties related to autonomous vehicles, which are much more complex and significantly surpass the uncertainties of most of the emerging technologies and how the framework of responsible innovation[23] (RI) can help with this issue. RI is „taking care of the future through collective stewardship of science and innovation in the present" (Stilgoe et al. 2013).
RI addresses situations in which the knowledge related to technology is uncertain and consensus has not been achieved in certain areas, thus the traditional approaches which manage responsibility subsequently with the instruments of responsibility or damages cannot function properly (Arnaldi et al. 2016). Instead, RI emphasises a more comprehensive approach of responsibility. Accordingly, RI can be an efficient response to this dual uncertainty (lack of knowledge and disputability of consensus).
Von Schomberg (2012) highlighted that the ultimate challenge lies in a more sensitive, more adaptive and more integrated management of the innovation process. The multidisciplinary approach involving stakeholders should lead to an inclusive innovation process in which technical innovators can respond to societal needs and in

[23] The responsible research and innovation (RRI) and responsible innovation (RI) frameworks differ in some way. RRI comes from an institutional setting while RI comes from academic field. In this paper, we will use the term RI meaning that substantive values and norms would guide the innovation process.

which social actors themselves also become responsible for the innovation process through constructive contribution provided in terms of defining socially desirable products.
On the basis of the above, in our present research we address the question: **how can responsible innovation contribute to the most socially desirable outcome of AVs?**
To get a better picture about the relationship of RI and AV technology, we conducted a systematic literature review, and tried to identify the main elements and common points that we need to focus to make the development and the spread of AV technology more socially desirable.
Our study is built as followings: in the first paragraph we analyse autonomous technology in the approach of responsible innovation with the help of systematic literature review. It is followed by the discussion of the results, and finally we close our study with the conluding thoughts.

2 Autonomous technology in the approach of responsible innovation

Autonomous vehicles can be categorised as an emerging technology due to several characteristics. Emerging technologies (such as gene therapy, robotics, or, for that matter, autonomous vehicles) can transform entire industries or strategies, furthermore, they can entail the creation of new industries (Day ¬ Schoemaker 2000). One of the specificities of emerging technologies is that new technologies often considerably disrupt the existing path of technical development by relying on new or different scientific bases and thus they require a lengthy improvement process of new competences. Nevertheless, it is important to emphasise that in the earliest stage of development it is often unclear what social advantages a new technology will realise later. Consequently, uncertainty is extremely high in this phase as there is no sufficient information in terms of the patterns and behaviours of consumer usage, in addition, there is also a lack of solid market knowledge, and the structure of market competition is rudimentary.
Several open questions have been raised regarding emerging technologies. In the case of these technologies, high uncertainty and ethical challengess must be taken into account, among others (Baumann et al. 2018, Lukovics et al. 2018). An increasing number of authors note that autonomous vehicles and their technological components (e.g., artificial intelligence) have special features which highlight the deficiencies in the conceptual system of responsible innovation.
In order to explore the relationship between self-driving or autonomous vehicles and responsible innovation, we conducted a literature review, in the course of which we collected and analysed the literary precedents written in this topic (Figure 1.). The basis of the analysis of international literature was provided by Google Scholar database.

We searched for the following keywords in the database: apart from responsible innovation, we studied the appearance of autonomous vehicle, autonomous car, and self-driving car in scientific articles. In accordance with the search parameters, we had 440 search results. We experienced when collecting literature that the scientific community have currently lack of information on this subject, thus this topic is worth exploring in more depth. In the next step, we further narrowed down the list of references and filtered the sources which were actually relevant in terms of our research. In this step we selected those literatures that highlight the relationship of responsible innovation and AVs or the main elements of autonomours vehicles (like artificial intelligence). Also, we selected those ones that examined how AV and the elements or dimensions of RI how can be in connection with each other (eg. ethics).

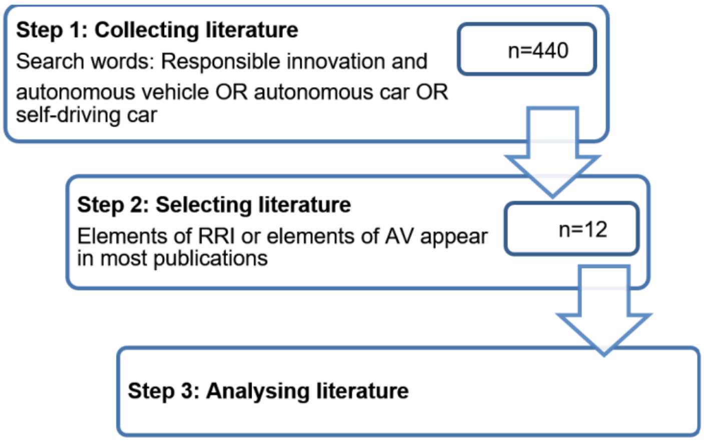

Fig.1 Research methodology

Source: own construction

Narrowing down the sources generated 12 search results in total (Table 1). Due to the novelty of the topic and rather limited number of search results, we broke down RRI and autonomous vehicles in our research, therefore, we also processed studies which examine certain key elements of RRI (for example, ethics) and autonomous vehicles, or, vice versa, focus on the analysis of responsible innovation and certain elements of autonomous vehicles (for example, artificial intelligence).

Author	Central argument of the article
Brundage (2016)	The author examines the relationship of artificial intelligence, as one of the basic technologies of autonomousvehicles, and responsible innovation.
Santoni de Sio (2016)	The author directly examined the relationship between responsible innovation and AVs.
Cohen et al. (2018)	The authors addressed how policymakers can be made to commit in terms of the opportunities of autonomous vehicles while examining the relationship between responsible innovation and AVs.
Stilgoe (2018)	In terms of the relationship of AVs and responsible innovation, the author puts a major focus on the role of machine learning and social learning in governmental measures.
Baumann et al. (2019)	The authors studied the issues and dilemmas considering the insurance of autonomous vehicles from the perspective of responsible innovation.

González González et al. (2019)	The authors examined self-driving technologies and their effect on and relationship with urban transport from the perspective of responsible innovation.
Nogués et al. (2020)	They address how urban planning could support the spread of AV technology with a backcasting methodology.
EC (2020)	The report examines the interpretation of AVs in the context of responsible innovation.
Stilgoe Cohen (2021)	The authors studied the relationship between one of the key elements of responsible innovation, public engagement, and autonomous vehicles.
Buhmann Fieseler (2021)	The article aimed to study artificial intelligence as an emerging technology defining AVs in the conceptual system of RI.
Grindsted et al. (2022)	The authors conduct a critical investigation on the role of autonomous vehicles in the plans about urban future in the context of responsible innovation.
Stahl (2022)	The author examines the relationship between artificial intelligence as one of the building blocks of AV technology and ethics as one of the key elements of responsible innovation.

Table 1. Summary of the literature review

Source: own construction

After processing the literature, we categorised the selected sources into two main groups: one group contains the articles investigating the direct relationship between responsible innovation and AVs, while the other group involves the ones studying the relationship between one of the most important technologies of AVs, artificial intelligence and responsible innovation.

2.1 Responsible innovation and autonomous vehicles

Santoni de Sio (2016) examined the relationship of responsible innovation and autonomous vehicles directly. In the article, the author presents some of the main ethical issues raised in the case of automated driving systems (ADS) and provides recommendations. The author proposes the approach of responsible innovation and value-sensitive design to manage ethical challenges. The concept of meaningful human control was introduced, and the author refers to it as the basis of a policy approach which prevents the morally unacceptable risks of human safety and foresees the issues of ethical and legal responsibility for accidents.

The article points out that in broader social terms, autonomous vehicle developers, who must consider complex socio-technical values, may face several challenges. It is a significant concern regarding autonomous robots and vehicles that their use may lead to unacceptable “responsibility gaps”, i.e., circumstances in which a serious accident happens where nobody can be held accountable due to the unpredictability or non-transparency of the process leading to the accident. Therefore, the system must be designed to prevent the hazardous behaviour of self-driving technology, and when it still happens, somebody can be held responsible and punished.

Santoni de Sio (2016) put together a package of proposals, which emphasizes the need to acquire and apply the methodology of responsible innovation and value-sensitive design in the development of autonomous technology, which enables to create the conditions for interdisciplinary foresight analyses which aims to embed ethical values into future socio-technical automated driving systems. The author recommends the application of a more comprehensive ethical approach, which intends to improve safety by decreasing the number of accidents caused by human error and avoiding new risks (new fatal accidents) negatively influencing human safety; as well as to enhance human moral and legal responsibility and respect individual rights.

Stilgoe (2018) mentions that autonomous vehicle as an emerging technology is a very important tool of the development and application of machine learning. The emergence of autonomous vehicles represents a test for social learning, which refers to how society and its institutions interpret the novelty. Stilgoe (2018) studies and analyses the public debates about the innovation of autonomous vehicles, with special attention to problems, solutions, and concerns about the technology.

In his research on autonomous vehicles, Stilgoe (2018) relied on some informal online discussions between users involved in the process of random social learning. In this respect, he emphasises that the insistence of innovators and developers on the idea that in the development of autonomous vehicles, the answer is to be found in continuous autonomy and the development of algorithms leads to the rejection of new forms of governance and refers to substantial privatisation of learning. It may jeopardise public confidence on the part of society, as well as the long-term potential of technologies which would represent a significant advantage for society. In his analysis, Stilgoe (2018) points out several governance opportunities which intend to focus on social learning in the case of autonomous technologies, including sharing of data, in particular.

Cohen et al. (2018) intended to find out how policymakers can be made committed to autonomous vehicles. The study aimed at extending the debate about the governance of autonomous vehicles and thereby expanding the disputes over responsible innovation. The authors focus on currently neglected questions which provide a basis for a constructive debate about technology governance. They outline a new vision regarding the role of public bodies in developing the future of autonomous technology. The authors point out that AVs, as experimental technology are suitable to provide a rich understanding of social sciences related to emerging technologies and responsible innovation (Cohen et al. 2018). The authors believe the case of autonomous vehicles reveals some deficiencies in current studies about responsible innovation. A key challenge is to connect experimenting and forecasting.

Cohen et al. (2018) emphasise that every approach of governance and government decisions which relies on technologically determinist assumptions probably cannot be efficient enough, thus preliminary assumptions should be avoided. It is difficult but essential for governments to prevail over technological hubris. It is important that the adequate governance of AVs cannot take a competitive form, we must not compare our situation to others. It is crucial that they formulate coherent ideas about a desirable future transport already in the early stage and manage autonomous vehicles

accordingly. It requires the management of disruptive and utopian innovations with organised incremental policies.
They also emphasise that instead of a traditional risk-based regulation, a constructive relationship with an uncertain future may require a new model of "experimentalist governance" (Cohen et al. 2018). The authors point out that there is room for open reflection processes regarding AV technology and the main challenge will be to connect government forecast with the governance of ongoing self-driving tests. The authors note that innovation and investment related to AV technology clearly requires an active engagement of management bodies, which rely on critical social science research.
Baumann et al. (2019) studied the issues and challenges related to the insurance of autonomous vehicles from the perspective of responsible innovation. The authors point out that insurance companies can be considered as stakeholders with a great influence in negotiation and introduction processes related to autonomous technology. Insurers face issues regarding ethical or social consequences, which may arise not only in connection with the promotion of the technology but also with insurance models which can contain discriminative elements (e.g., "pay as you drive" model, where the insurance model changes depending on the driving style). The concept of responsible innovation can be a suitable tool to involve and guide insurance companies, policymakers, and other stakeholders in a responsible negotiation process, which can be beneficial for everyone. The RI approach can help stakeholders learn about the soft factors influencing innovation (such as ethical, societal, or historical factors), as well as the necessity to involve these aspects in their activities responsibly.
One of the authors' important findings is that existing regulations are insufficient to prevent the potential damages which can be caused if the companies producing and using the data from the vehicles fail to take ethical and social issues seriously in terms of self-driving technology. Thus, responsible innovation is crucial for insurance companies to be able to define their responsibility and then act accordingly without losing the trust of their clients. The authors note the significance of mutual response, which would mean making their insurance practice transparent for the public, in addition to a role of active cooperation with other stakeholders and active engagement in the social discourse about autonomous driving.
González-González et al. (2019) studied AV technologies and investigated its impact on and relationship with urban transport. The authors reveal that divergent and sometimes contradictory estimations and opinions cause considerable uncertainty among urban policymakers and can occasionally lead to planning issues and doubts. The authors intended to show the potential offered by AVs in the implementation of attractive, healthy, and sustainable urbanisation opportunities. In their study, they use the so-called backcasting approach to examine whether the potential effects of AV implementation can support or jeopardise urban development policy goals. This method allows to identify the conflicts between policy objectives. Planners and urban

policymakers need to start elaborating adaptive plans and programmes in order to project future changes caused by AV technology. Backcasting approaches can help forecast planning measures which could be the most favourable and reduce occasional negative consequences.

The authors highlight the importance of a mixed land use policy, the development of urban facilities and services, the acceptance of shared mobility services, and the necessity for a high-quality multimodal transport system (González-González et al. 2019). This set of principles can help policymakers and other stakeholders and actors understand the introduction of AVs and make decisions. In the context of participatory governance, urban stakeholders cooperating with authorities have a key role in the development of these policy frameworks and objectives.

Nogués et al. (2020) also investigated the potential of AV technology application in an urban environment. The authors note that the future introduction and use of autonomous vehicles in cities may have substantial positive and negative effects on sustainability and, on that basis, the main aim of the article is to study these effects and assess which policies would be the most efficient to achieve a desired urban scenario. For this they rely on backcasting planning methodology. Authors suggest that it is important to make political decisions which can reduce negative effects the most efficiently. Authors also described that the majority of the interviewed experts believed that the presented programmes of policy measures could mostly be efficient to achieve the most desirable scenario. It is thus important that the implementation of AVs should not subordinate but reinforce the sustainable mobility and land use policy already in preparation in an urban area.

The European Commission (2020) prepared a report which aims to facilitate a safe and responsible transition to connected and autonomous vehicles (CAV) by supporting stakeholders in the systematic integration of ethical aspects during the development and regulation of CAVs (EC 2020). The report applies the approach of responsible innovation on CAVs. This approach acknowledges the potential of CAV technology in achieving the advantages of autonomous vehicles, but it also recognises that technological development alone is not sufficient to realise this potential. In order to achieve desired results, the vision about CAVs must integrate a broader range of ethical, legal and social considerations into the development, installation, and use of CAVs.

According to the approach of responsible innovation, the design and implementation of connected and automated vehicles must rely on ethical directives based on socially accepted basic ethical, and legal principles (EC 2020). The authors emphasise the establishment of clear ethical and legal standards of responsibility. Furthermore, inclusive deliberations allow every social group's perspective to be heard and nobody to be ignored. Consequently, the design and development of CAV systems must support inclusive deliberation processes engaging stakeholders and the wider public and must be implemented as their outcome.

Stilgoe and Cohen (2021) studied the relationship between autonomous vehicles and the key element of responsible innovation, public engagement. In their article, they outlined a dominant public engagement model relying on increased awareness of the public, which can lead to the acceptance and adoption of technology. The authors concluded that public dialogue could contribute to changing the ideas formed about technology and public, however, this process requires openness on the part of policymakers and other stakeholders. Instead of considering public dialogues as individual practices, it would be better to evaluate the governance of emerging technologies from whether it takes place “in a dialogue”, i.e., the widest possible range of stakeholders are involved in the process of creating and developing the technology. Stilgoe and Cohen (2021) therefore analyse how the views of innovators and policymakers about the public are connected to their views about autonomous vehicles. The authors drew optimistic conclusions, namely that public dialogue can contribute to the constructive change and development of debates related to the tools and goals of technology, as a part of the social learning process. For this, however, it is first important to identify the assumptions embedded at institutional level which can hinder willingness and inclination to change. In the course of a public dialogue, the authors intended to find out how citizens imagine the future of AVs and how more democratic approaches of governance can enable greater consistency between technological visions and public values. The authors emphasised that the application of social science (especially psychological) aspects in debates about autonomous vehicles can be considered a crucial factor. Furthermore, they claimed that the more the public learns and knows about a technology, the more uncertainty is reduced. Consequently, a technology can be best known in the context of testing. Public dialogues can be an important part of how policymakers interpret new technologies and how they can change their own views by public opinion.

Grindsted et al. (2022) conducted a critical investigation on the role of autonomous vehicles in plans about urban future. In their study, they examine the urban plan of 10 European capitals in terms of expected promises and threats of autonomous vehicles. The authors propose a practice-based view of automation to facilitate sustainable mobility transition. In the examination, the authors concluded that none of the plans of the studied 10 capitals addresses the possibility of aligning AV technology with means of public transport or renewable energy sources. An important finding of the article is that AVs are very likely to further individualise and reinforce the current mobility system and harmful emissions will probably increase in the near future. To avoid this, the authors emphasise that urban policy making has a significant role in the application of AV technology and it is their important task to discuss the existing technology-centred concept of autonomous vehicles in order to facilitate the sustainable development goals of cities.

The authors note that the field of mobility can raise several dilemmas and challenges and they emphasise the consideration of environmental aspects in the process of urban mobility planning (Grindsted et al. 2022). It is essential to rethink urban transport according to the new mobility paradigm and to focus on connecting different modes of transport, in the framework of which the shift from ownership to access and use of vehicle (Mobility as a Service ¬ MaaS) can have a crucial role. It can be concluded that the urban planning process of autonomous vehicles may entail planning paradoxes, several advantages, and a broad scale of threats/dilemmas (Grindsted et al. 2022).

2.2 Artificial intelligence and responsible innovation

Stahl (2022) in his publication relies on the debate about the ethics of artificial intelligence to explore how responsible AI innovations ecosystems can be developed and implemented. In his study, the author argues that the current innovation ecosystem discourse does not pay sufficient attention to ethical issues. The author suggests that discussing responsible innovation and integrating it into the literature and practice of innovation ecosystems to discuss and consider ethical and social awareness is crucial. The author emphasises that RI takes place within innovation ecosystems, but it also shapes these ecosystems and can result in new innovation ecosystems. The publication attempts to examine whether it is possible to create a responsible innovation ecosystem and if yes, how it would be constructed. For providing practical background and illustration, the article applies the conceptual framework of innovation ecosystems and RI on artificial intelligence, with special attention to the current debate about the ethical and human right aspects of artificial intelligence.

The author points out several ethical challenges which can be associated with artificial intelligence (Stahl 2022). Regarding the characteristics of certain artificial intelligence techniques (namely, machine learning), broader concerns arise with regard to how artificial intelligence can support other socio-technical systems and how they influence our lives.

Buhmann and Fieseler (2021) in their study examined the relationship of responsible innovation and artificial intelligence (AI) as the basic technology operating autonomous vehicles. They used a deliberative approach to provide a framework for the relationship of artificial intelligence and responsible innovation. This framework focuses on discourse principles which aim to help counterbalance the challenges related to the non-transparency of technology.

According to Buhmann and Fieseler (2021), one of today's greatest challenges is the sustainable facilitation of artificial intelligence. This challenge could be resolved by procedures of participatory technological design and public forums, in which systemic compromises related to AI governance can be discussed and agreed upon. While tackling this challenge, however, in terms of reflecting on responsible innovation, it is important to consider how weak transparency, explicability, and accountability of artificial intelligence can be counterbalanced to enable responsible AI governance.

In their article, the authors address the prospects and challenges of artificial intelligence in terms of responsible innovation (Buhmann Fieseler 2021). In particular, they focus on the role and functions of public forums in order to explore the paths leading to engagement in technological design and give recommendations about how a society could deliberate the systemic compromises related to AI governance and what agreement they could reach.

Regarding the relationship of artificial intelligence and responsible innovation, the authors note that communicative and deliberative approaches can provide adequate solutions for unintended negative consequences of artificial intelligence and the apparent non-transparency of the technology (Buhmann Fieseler 2021). The authors emphasise that deliberation seems to be a necessary but contested process to facilitate the responsible innovation of artificial intelligence. In this context, they highlight the role of stakeholder engagement.

Brundage (2016) studies the relationship of artificial intelligence as one of the basic technologies of autonomous vehicles with responsible innovation. The author points out that the literature of responsible innovation can substantially enrich the analyses about the social dimensions of artificial intelligence. Brundage (2016) suggests that the framework of responsible innovation offers a useful approach to integrate the understanding of social dimensions of artificial intelligence into the innovation ecosystem more deeply.

Brundage (2016) mentions two main reasons according to which the limitations regarding the social dimensions of artificial intelligence must be addressed and the responsible innovation of artificial intelligence requires a more comprehensive approach. One of the reasons is that the nature of artificial intelligence research will develop over time, as well as its potential social consequences. Thus, a deeper integration of anticipation, reflexivity, and other aspects of responsibility into the practice of research itself is essential to take care of the future. The other reason is that the clearly structured, flexible framework of the responsible innovation of artificial intelligence can help identify the deficiencies of existing efforts and thereby facilitate the productive future work on the social dimensions of artificial intelligence.

2.3 Results of literature analysis

The literature analysis revealed that the approach of responsible innovation would lead to significant results in exploring and addressing the social dimensions of autonomous vehicles. The analysis of the results of the literature review is based on the RI keys and dimensions. To make abstract definitions of RI more concrete and practical, theorists and policy makers have sought to operationalize the concept in terms of content and process. Regarding the process of responsible innovation, four main dimensions can be distinguished: anticipatory, reflective, deliberative and responsive dimension (Stilgoe et al. 2013). The European Commissions identified 5 main key

elements, the consideration of which can also help us to develop responsible innovation processes: public engagement, ethics, gender equality, science education and open access (EC 2014). The gender equality key was not relevant in case of our study, thus we only take into account the other 4 factors.
The authors also note that out of the four dimensions of RI, anticipation and reflexivity are of particular importance. Some pieces of literature highlight the importance of ethical issues and formulate recommendations considering some main ethical questions.
The reviewed literature encourages the interpretation of AVs in the approach of responsible innovation, in which a wider range of ethical, legal and social considerations must be integrated into developments related to autonomous vehicles. In this regard, the authors prioritise inclusive deliberation and stakeholder engagement, deliberative approach, and the process of participatory technological design.
Table 2 illustrates that the processed sources came to similar conclusion concerning on several points. The majority of the processed sources deal with some ethical concern or issue and emphasise how crucial it is to outline and discuss ethical issues in the design process of AV. Another important agreement in the above-mentioned references is that they give priority to the significance of public engagement.

RI factors	Buhmann Fieseler (2021)	Cohen et al. (2018)	Santoni de Sio (2016)	Baumann et al. (2019)	EC (2020)	Stilgoe (2018)	Brundage (2016)	Stilgoe Cohen (2021)	Grindsted et al. (2022)	González-González et al. (2019)	Nogués et al. (2020)	Stahl (2022)
Ethics	x	x	x	x	x			x	x			x
Public engagement	x	x	x	x	x	x	x	x	x	x	x	
Open access				x								
Scientific education												
Anticipatory dimension			x				x			x	x	
Reflective dimension							x					
Deliberative dimension	x	x		x	x	x	x	x	x	x	x	
Responsive dimension	x			x	x	x	x	x	x	x	x	x

Table 2 Appearance of the elements of responsible innovation in each AV publication

Source: own construction

Several authors mentioned the importance of participatory technological design, stakeholder involvement, proactive cooperation and engagement and the application of a deliberative approach. Furthermore, the majority of the articles also considers it important not only to listen to the opinion of society members but also to integrate it into technological design and application.
In the course of literature research, it became obvious that several authors mention – or at least refer to – that in the contexts of autonomous vehicles, the framework of responsible innovation may have shortcomings. Most authors connect these deficiencies to ethical challenges, which we find totally justified. Especially in the light of the fact that, based on 40 million responses in 233 countries around the world, the famous Moral Machine research of the MIT, that failed to produce results which could have shown a clear direction for the machine ethics development of autonomous vehicle developers (Awad et al. 2018). In addressing the ethical challenges related to autonomous vehicles, Santoni di Sio identifies the deficiency of responsible innovation, and proposes the approach of Value-Sensitive Design to complement RI methods.
Another apparent finding of our analysis on the literature intending to explore the relationship between responsible innovation and autonomous vehicles was that considering "public engagement" key element of RI, the authors predominantly focused on autonomous vehicles as a means of passenger transport and formulated their statements accordingly. In their work they mostly study the vehicle from inside, which resonates with the mainstream trend of technology acceptance analyses related to autonomous vehicles.

3 Conclusions

The significance of the application of RI in the development of autonomous vehicles may be more important than ever. One of its reasons is that AV technology affects the life of all people living in modern societies regardless of whether they are active users of AV technology or not. Given that it is an emerging technology associated with a high level of uncertainty, several questions can arise during the development, adoption and acceptance of the technology and addressing them requires the approach and concepts of responsible innovation. The examination of the relationship between responsible innovation and technology revealed several facts which suggest that the application of RI is justified. The literature highlighted several deficiencies which can be addressed by using the framework of RI.
One important finding is that technological development alone is not sufficient to make a technology safely applicable in practice, thus the various ethical challanges must not be ignored, they must be considered and addressed in a proactive ethical approach. Nevertheless, it is to be noted that it requires a joint effort. Therefore, in this respect, the process of participatory technological design, a deliberative approach, as well as

active cooperation and engagement are all essential, engaging the widest possible range of stakeholders and the public in the process of technological design and urban planning in order to create solutions which fully comply with the expectations and interests of society. Public forums and workshops can provide a suitable framework for this.

We believe that public engagement should be realised in a special socio-technical integration which is embedded in the framework of RI. This framework allows everyone to tell and explain their own position, opinion, and experience about the entire ecosystem of autonomous technology. On the other hand, for innovators and policymakers in charge of a safe and responsible implementation of technology, it would mean an intensive input gathering process, in which the information and recommendations could be considered, discussed, and integrated in later stages for technology development, and could affect future developments as a sort of learning process. Therefore, we suggest that it is important to involve the widest possible range of society in research and innovation processes conducted within the framework of responsible innovation from the initial stage, extended to the entire autonomous vehicle ecosystem, as well as to encourage active cooperation and responsibility in order to produce socially accepted innovation results. In the next phase of the research, we will conduct its operationalisation.

It is important to highlight that our study has some limitations. First of all, the number of studies available in the field of AV technology and the RI concept is limited, and many of the above-described papers concerns the relationship of RI and AV in a theoretical way, and in many times just elements of RI or AV are examined, and not the whole phenomenon in a complex way. Moreover, our study is based on theoretical background, thus the empirical evidence is missing. Thus, the next step is to make some empirical research to support our findings.

References

Alazzawi, Sabina; Hummel, Mathias; Kordt, Pascal; Sickenberger, Thorsten; Wieseotte, Christian; Wohak, Oliver (2018): Simulating the impact of shared, autonomous vehicles on urban mobility – A case study of Milan. In Wießner, E.; Lücken, L.; Hilbrich, R.; Flötteröd, Y-P.; Erdmann, J.; Bieker-Walz, L.; Behrisch, M. (eds.): SUMO 2018 – Simulating Autonomous and Intermodal Transport Systems, 2, pp. 94–110. https://doi.org/10.29007/2n4h.

Alfonso, Jorge; Naranjo, José E.; Menéndez, José. M.; Alonso, Arrate (2018): Vehicular Communications. Intell. Veh., Elsevier, pp. 103–139. doi: 10.1016/B978-0-12-812800-8.00003-5

Arnaldi, Simone; Gorgoni, Guido; Pariotti, Elena (2016): RRI as a governance paradigm: What is new? https://arts.units.it/retrieve/handle/11368/2922006/258500/Responsible_Research_and_Innovation_as_a_governance_paradigm.pdf Letöltve: 2021.05.25.

Atzori, Luigi; Floris, Alessandro; Girau, Roberto; Nitti, Michele; Pau, Giovanni (2018): Towards the implementation of the Social Internet of Vehicles. Comput. Networks, 147, pp. 132–145. doi: 10.1016/j.comnet.2018.10.001

Awad, Edmond; Dsouza, Sohan; Kim, Richard; Schulz, Jonathan; Henrich, Joseph; Shariff, Azim; Bonnefon, Jean-François; Rahwan, Iyad (2018): The moral machine experiment. Nature, 563, 7729, pp. 59-64.

Baumann, Martina F.; Brändle, Claudia; Coenen, Christopher; Zimmer-Merkle, Silke (2019): Taking responsibility: A responsible research and innovation (RRI) perspective on insurance issues of semi-autonomous driving. Transportation research part A: policy and practice, 124, pp. 557-572.

Bezai, Nacer E; Medjdoub, Benachir; Al-Habaibeh, Amin; Chalal, Moulay L.; Fadli, Fodil (2021): Future cities and autonomous vehicles: analysis of the barriers to full adoption. Energy and Built Environment, 2 (1), pp. 65-81.

Brundage, Miles (2016): Artificial intelligence and responsible innovation. In Müller, V. C. (ed.) (2016): Fundamental issues of artificial intelligence. Springer, Cham, pp. 543-554.

Buhmann, Alexander; Fieseler, Christian (2021): Towards a deliberative framework for responsible innovation in artificial intelligence. Technology in Society, 64, 101475.

Cohen, Tom; Stilgoe, Jack; Cavoli, Clemence (2018): Reframing the governance of automotive automation: insights from UK stakeholder workshops. Journal of Responsible Innovation, 5 (3), pp. 257-279.

Combs, Tabitha S.; Sandt, Laura S.; Clamann, Michael P.; McDonald, Noreen C. (2019): Automated Vehicles and Pedestrian Safety: Exploring the Promise and Limits of Pedestrian Detection. Am. J. Prev. Med, 56, pp. 1–7.

Day, George S.; Schoemaker, Paul J. (2000): Avoiding the pitfalls of emerging technologies. California management review, 42 (2), pp. 8-33.

EC (2014): Responsible Research and Innovation. Europe’s ability to respond to societal challenges. European Commission, Brussels. https://ec.europa.eu/research/swafs/pdf/pub_rri/KI0214595ENC.pdf Access: 2016.06.11.

EC (2020): Ethics of Connected and Automated Vehicles: recommendations on road safety, privacy, fairness, explainability and responsibility. Publication Office of the European Union, Luxembourg.

Fagnant, Daniem J.; Kockelman, Kara M. (2016): Dynamic ride-sharing and fleet sizing for a system of shared autonomous vehicles in Austin. Texas, Transportation (Amst) 45, pp. 143–158.

González-González, Esther; Nogués, Soledad; Stead, Dominic (2019): Automated vehicles and the city of tomorrow: A backcasting approach. Cities, 94, pp. 153-160.

Grindsted, Thomas S.; Christensen, Toke H.; Freudendal-Pedersen, Malene; Friis, Freya; Hartmann-Petersen, Katrine (2022): The urban governance of autonomous vehicles–In love with AVs or critical sustainability risks to future mobility transitions. Cities, 120, 103504., pp.1-9.

Kesselring, Sven; Freudendal-Pedersen, Malene; Zuev, Dennis (2020): Sharing mobilities: New perspectives for the mobile risk society. New York and London: Routledge.

Kim, Shiho (2018): Blockchain for a Trust Network Among Intelligent Vehicles. Blockchain Technol. Platforms, Tools Use Cases, 1st ed., Elsevier Inc, pp. 43–68.

Liljamo, Timo; Liimatainen, Heikki; Pöllänen, Markus (2018): Attitudes and concerns on automated vehicles. Transp. Res. Part F Traffic Psychol. Behav. 59, pp. 24–44.

Liljamo, Timo; Liimatainen, Heikki; Pöllänen, Markus; Viri, Riku (2021): The Effects of Mobility as a Service and Autonomous Vehicles on People's Willingness to Own a Car in the Future. Sustainability, 13 (4), 1962.

Lipson, Hod; Kurman, Melba (2016): Driverless: intelligent cars and the road ahead. Mit Press.

Litman, Todd (2017): Autonomous Vehicle Implementation Predictions: Implications for Transport Planning. Transp. Res. Board Annu. Meet, 42, pp. 36–42.

Lukovics, Miklós; Udvari, Beáta; Zuti, Bence; Kézy, Béla (2018): Az önvezető autók és a felelősségteljes innováció. Közgazdasági Szemle, 65 (9), pp. 949-974.

Martinez, Luis M.; Viegas, José M. (2017): Assessing the impacts of deploying a shared self-driving urban mobility system: An agent-based model applied to the city of Lisbon, Portugal" International Journal of Transportation Science and Technology, 6, pp. 13–27. https://doi.org/10.1016/j.ijtst.2017.05.005.

Nogués, Soledad; González-González, Esther; Cordera, Rubén (2020): New urban planning challenges under emerging autonomous mobility: Evaluating backcasting scenarios and policies through an expert survey. Land Use Policy, 95, 104652.

Overtoom, Irene; Correia, Gonçalo; Huang, Yilin; Verbraeck, Alexander (2020): Assessing the impacts of shared autonomous vehicles on congestion and curb use: A traffic simulation study in The Hague, Netherlands. International Journal of Transportation Science and Technology 9 (3), pp. 195-206.

Santoni De Sio, Filippo (2016): Ethics and Self-driving Cars: A White Paper on Responsible Innovation in Automated Driving Systems.

von Schomberg, René (2012): Prospects for technology assessment in a framework of responsible research and innovation. In R. Dusseldorp; M. Beecroft (eds): Technikfolgen Abschätzen Lehren: Bildungspotenziale Transdisziplinärer. Wiesbaden: VS Verlag für Sozialwissenschaften. pp. 39–61.

Spurling, Nicola; McMeekin, Andrew (2014): Interventions in practices: Sustainable mobility policies in England. In Y. Strengers, ¬ C. Maller (Eds.) (2014): Social practices, intervention and sustainability. London: Routledge.

Stahl, Bernd C. (2022): Responsible innovation ecosystems: Ethical implications of the application of the ecosystem concept to artificial intelligence. International Journal of Information Management, 62, 102441.

Stilgoe, J. ¬ Owen, R. ¬ Macnaghten, P. (2013): Developing a framework for responsible innovation. *Research Policy*, 42 (9), pp. 1568–1580.

Stilgoe, Jack (2018): Machine learning, social learning and the governance of self-driving cars. Social studies of science, 48 (1), pp. 25-56.

Stilgoe, Jack; Cohen, Tom (2021): Rejecting acceptance: learning from public dialogue on self-driving vehicles. Science and Public Policy, 48 (6), pp. 849-859.

Straub, Edward R.; Schaefer, Kristin E. (2019): It takes two to Tango: Automated vehicles and human beings do the dance of driving –Four social considerations for policy. Transportation research part A: policy and practice, 122, pp. 173-183.

Threlfall, Richard (2018): Autonomous vehicles readiness index. Klynveld Peat Marwick Goerdeler (KPMG) International.

Activating Energy Communities for Systemic Change

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Abstract. The speed of energy transition in the Netherlands is low, in contrast to its 2050 climate change target of net-zero emissions. The transition requires 7.5 million households with natural gas connections, to move to renewable energy sources. The main challenge is not technical, many viable options are already available, but social: people will need to be supported to decide and act. In this paper, we identify interventions that could activate change within energy communities, through 19 interviews conducted in March 2021 in Austerlitz, Zeist municipality, The Netherlands. Interview questions were guided by the Capability, Opportunity, Motivation, and Behavioural (COM-B) change model. The model explains factors that affect people's behaviour. Results indicate that renovation and energy transition are viewed as two separate processes. Austerlitz homeowners are waiting for the government to lead the energy transition process, while they continue to renovate their homes to improve comfort, aesthetics, safety, and convenience. Also, current interventions towards activating households are piecemeal and more focused on creating external opportunities (such as financial support), and barely address the psychological capabilities and motivation factors (belief, attitude, social norm, and perceived behavioural control). To boost psychological capabilities and motivation, we recommend interventions that enhance homeowners' belief that the energy transition is part of their long-term home renovation plans, for their own benefit, to motivate them to drive the energy transition process. Interventions may include 'show' or 'display' houses where energy transition was combined with renovations and highlighting inspirational energy transition stories on the municipality website.

1 Introduction: Energy transition, a social challenge

On June 28th, 2019, the Netherlands agreed to a net-zero emissions by 2050 (Ministry van Economische Zaken en Klimaat, 2019). The scale of financial resources required to enforce gas discontinuation top-down, wherein individuals play essentially no decisive role, are indeed not available. With more than 7.5 million gas connections for Dutch households (Ebrahimigharehbaghi et al., 2019), reaching the net-zero emissions goal, is an immense challenge. Several studies indicate that the energy transition rate of The Netherlands is far too low to achieve the ambitious 2050 climate change target (Steenbekkers and Scholte, 2019, Ebrahimigharehbaghi et al., 2019, Broers et al., 2019, Filippidou et al., 2017). By and large, the Dutch energy transition approach has so far been technocratic, with an emphasis on exploring alternatives to natural gas heating systems e.g., all-electric, heat pumps, residual heat, geothermal systems (Raven and Verbong, 2007, Klaassen and Patel, 2013).

The great, yet often neglected challenge lies in activating households to adopt these already available technologies, not as a one-off event, but as part of their everyday life (Steg et al., 2021, Nash et al., 2019). Many viable options are available, but people will need to be activated to decide and act (Steenbekkers and Scholte, 2019). Studies reveal increasing awareness amongst citizens about the need for and value of sustainable lifestyles, yet it is not reflected in their behaviours and consumption patterns (Frederiks et al., 2015). This widens the gap between residents' intention to become sustainable and the corresponding action, the so-called intention-action gap or green gap (Thøgersen and Schrader, 2012, Vermeir and Verbeke, 2006). At the micro level, for a given household, the most viable alternative and sustainable energy source depends largely on contextual variables and is in any case associated with some investment (Steenbekkers and Scholte, 2019). For a household to substitute natural gas for an alternative sustainable energy source, insulation, window glazing and ventilation need to be upgraded (Broers et al., 2019). Even to adopt an alternative source of energy with the fewest required household-level adjustments (e.g., high temperature residual heat), associated costs are high and necessary infrastructural changes are substantial (Broers et al., 2019). The switch from natural gas to an alternative energy source, therefore, poses obstacles for households: investment and inconvenience in the short-term, and uncertainty in financial savings for the long-term (Liebe et al., 2011, Ligterink et al., 2019, Steenbekkers and Scholte, 2019, Jansma et al., 2020).

This paper seeks to increase the understanding of (un)sustainable energy behaviour and formulate interventions for municipalities to activate households. We specifically selected households rather than other energy users because "on the global level, 72% of greenhouse gas emissions are related to household consumption" (Hertwich and Peters, 2009). Thus, understanding household behaviour and how sustainable energy transition can be mobilised, at that level, is a critical component of climate policy (Dubois et al., 2019).

We held 19 semi- structured kitchen interviews, guided by the Capability, Opportunity, Motivation and Behavioural (COM-B) change model (Michie et al., 2015). The research objective is to understand different factors that may lead to either piecemeal, short-lived interventions or systemic interventions that spill over from one action to the next and the multiplier effect catalyses the much-needed change. The paper seeks to answer two research questions. First, what source of energy transition behaviour (capability, opportunity, and motivation) could activate systemic behavioural change at the household level? Second, what behavioural change interventions best address the identified system of behaviours? Findings bring to fore the value and limitations of the COM-B model in addressing systemic problems, where actions of millions of residents need to be sustained over long periods. We conclude that interventions should enhance homeowners' belief that energy transition is an intrinsic part of their long-term home renovation plans, to motivate them to drive the energy transition process. Moreover, the transition can be fast-tracked when households are financially enabled, and skills enhanced. The suggested approach will enhance homeowners' long-term engagement in energy transition, as main drivers of change.

The subsequent section reviews literature on behaviour change, introduces the behaviour change wheel and explains how the COM-B behaviour change model was operationalised in the research. In section 3, we contextualise the Austerlitz case study, and explain the methods, participants, and measures. Section 4 summarises the key findings. Finally, in section 5, we use the findings to identify which factors contribute to (un)sustainable behavioural spillover at the household level and formulate directions for interventions.

2 The COM-B Model of Behaviour and Intervention Functions

2.1 Behavioural change theories

Most behavioural change theories use the model of reasoned action to explain human action (Sahu et al., 2020, Nash et al., 2019). The Reasoned action model posits that energy consumers consider multiple options before making rational choices or decisions (Fishbein and Ajzen, 1977). However, when a decision is complex, uncertain, and involves large investments, it only makes sense for someone to act if several others have already acted and experienced positive results (Cialdini and Goldstein, 2004). Ajzen (1991) theory of Planned Behaviour (TPB) improves on the TRA by introducing perceived behavioural control (perceived ability to perform the behaviour) as a determinant of human action. According to TPB, if residents find the process too complex, most prefer to indefinitely defer energy transition decisions. Bem (1972)'s theory of self-perception further explains the present inaction. If people believe that natural gas is unsustainable and they need to transition to renewable energy sources but there is too much ambiguity, uncertainty and it is complex to even start the process, then they can either make the decision to immediately transition or adjust their belief system to justify inaction. In such circumstances, most people prefer not to act, leading to the present impasse where everyone is waiting for others to adopt sustainable energy sources, and consequently, nothing happens.

Reasoned action theories may not adequately predict human behaviour when applied in new contexts like energy transition, where information is lacking, conflicting or contested (Gilal et al., 2019, Hagger et al., 2002, Nash et al., 2017). Moreover, they fail to provide a formula for “wider lifestyle shifts” (Nash et al., 2017), at the household level. A person may make reasoned judgment on one behaviour (e.g., buy energy saving gadgets or install solar panels), but if they are not motivated to transition to renewable energy sources, they might not take up subsequent sets of behaviour to complete the entire process. Thus, to address these two main gaps in behavioural change theories, we decided to look closer into motivation, as a key component of behaviour change.

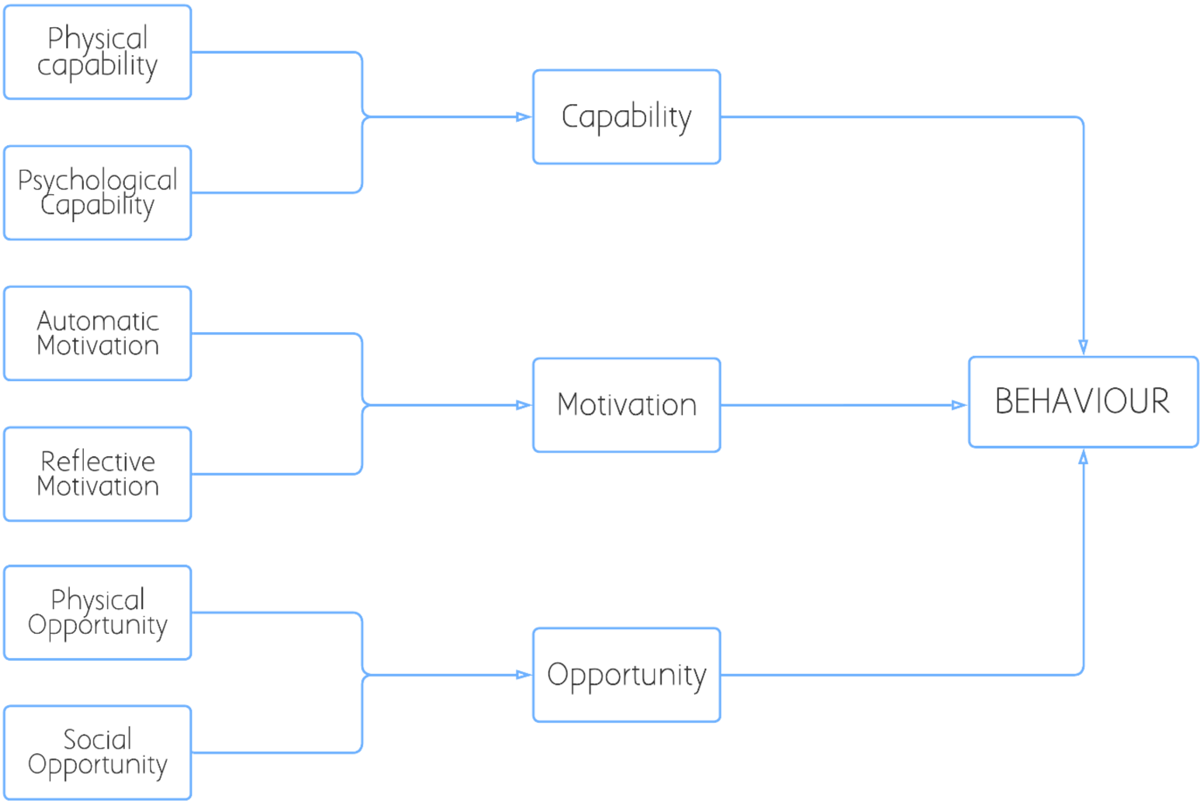
2.2 PRIME Theory and the COM-B Model

PRIME[24] theory was developed to integrate numerous motivation theories and models, into one coherent framework. According to the theory, the “decision to do something will not result in action unless it generates the desire to do it at the relevant moment” (West and Michie, 2019). PRIME theory places emphasis on strong voluntary desire to transition to sustainable energy sources, as a key predictor of human behaviour (West and Michie, 2020), and the formula for “wider lifestyle shifts” (Nash et al., 2017). To actualise the theory, many researchers adopt the COM-B model (Michie et al., 2015, West and Michie, 2019, West and Michie, 2020). We used the model to help us understand what the household’s intention is and how this intention can be activated to get the target behaviour. The COM-B model (see Fig. 1) consists of three main components, leading to a certain behaviour: capability, opportunity, and motivation.

Capability refers to a person’s knowledge, skills, physical strength, and mental stamina to act. It is the individual’s or household capacity to proceed with the energy transition, both physical (e.g., physical skills, stamina, or strength) and psychological (e.g., understanding or memory).

Physical capability was operationalised by adopting the Michie et al. (2015) approach, where individual skills (including knowledge) that enable a person to perform the target behaviour. We assessed whether the household had knowledge of the municipality energy policy, alternative energy options, home insulation options, approximate cost of the transition, how to mobilise resources or where to get professional support. Physical strength and stamina were not operationalised in this study since it is beyond the scope of this study.

[24] Planning, Response, Impulse / Inhibition, Motive and Evaluation Processes.



CAPABILITY: An attribute of a person that together with opportunity makes a behaviour possible or facilitates it.	PSYCHOLOGICAL CAPABILITY: Capability that involves a person's mental functioning (e.g., understanding / social skills / memory)
OPPORTUNITY: An attribute of an environmental system that together with capacity makes a behaviour possible or facilitates it.	REFLECTIVE MOTIVATION: Motivation that involves conscious thought processes (e.g., plans and evaluations / beliefs)
MOTIVATION: An aggregate of mental processes that energise and direct behaviour.	AUTOMATIC MOTIVATION: Motivation that involves habitual, instinctive, drive related and affective processes (e.g., wants, needs, inhibitions, reflexes, and impulses)
BEHAVIOUR: Individual's human activity that involves co-ordinated contraction of striated muscles controlled by the brain	PHYSICAL OPPORTUNITY: Opportunity that involves inanimate parts of the environmental system and time (finances / material resources / location / physical barriers)
PHYSICAL CAPABILITY: Capability that involves a person's physique, and musculoskeletal functioning (physical skills / knowledge / stamina / physical strength)	SOCIAL OPPORTUNITY: Opportunity that involves other people and organisations (interpersonal influences / culture / social norms)

Fig. 1. COM-B model of behaviour, modified from West and Michie (2020)

Psychological capability was operationalised by assessing whether households clearly understood three key components that have an impact on their future behaviour. First, their municipalities energy transition policy including the proposed alternative energy transition solution(s) (hydrogen, solar, wind etc.). Second, a clear understanding of the municipality's role (information provision / facilitation / resource mobilisation / actual implementation of the energy transition etc.). Third, whether the households understood their role in the energy transition. These three psychological capability questions are important because in 1959 when a large gas field was discovered in Groningen, cooking, hot water, and heat transition , in 98 percent of the Dutch households, was financed, managed, and driven by the government (Raad voor de

Leefomgeving en Infrastructuur, 2017, Ministerie van Economische Zaken, 2016, Verbong and Schippers, 2000). Fifty-nine years later, Dutch residents are facing a new form of energy transition. This time, the government does not have financial resources to implement top-down gas discontinuation, as they did in 1963. More than 7.5 million Dutch households with gas connections are expected to play a major role in the transition (Ebrahimigharehbaghi et al., 2019). Since the switch from coal to gas is still in the minds of the older generation, they may expect the same or even greater support from the government in the current transition (Dekker et al., 2016). Psychological capability questions aim to increase understanding of how citizens feel about being the main drivers of an energy transition process, to fulfil a climate change commitment, they did not make. People's psychological mental functioning and memory were not operationalised since they are beyond the scope of this study.

Opportunity refers to external factors, both physical (subsidies, grants, loans, or time) and social (e.g., social cues, interpersonal influences, and cultural norms) that facilitate homeowners' transition. We operationalised physical opportunity by asking three key questions. First, whether the households have time to look for various contractors to help them with the transition. Second, whether they can arrange another accommodation to go to when the contractors are renovating their homes. Finally, whether they received practical information from the municipality on the possibilities available for them to facilitate the transition. Social opportunity questions focused on two key areas. First, whether the households know people in their neighbourhood who have already started making energy transition changes in their homes (insulation, ventilation, solar panels, or induction cooking). We assess whether they had a chance to watch and be influenced their neighbours, as they installed various energy solutions, in accordance with the Cialdini and Goldstein (2004) social influence theory. The second question assessed whether switching from cooking with gas to induction / electric cooking is a problem. Induction or electric cooking is placed under social opportunity because previous research confirms the existence of cultural norms associated with natural gas cooking which is considered superior to induction cooking, that may hamper the transition process (Steenbekkers and Scholte, 2019).

Motivation is at the core of the conceptual framework (Fig. 1) and the fuel that drives change (Michie et al., 2011, Michie et al., 2015). It is the internal driving force for taking actions to discontinue gas use. Motivation is either automatic (wants, needs, inhibitions, reflexes, impulses / automatic imitation) or reflective (beliefs of what is good or bad and planning). Reflective motivation was operationalised by asking three key questions. First, whether the respondent believes that transitioning away from natural gas is good for the environment. Second, whether they believe that transitioning from natural gas would cost more than what they are incurring currently. Lastly, we enquired whether the respondent wants their neighbourhood to quickly transition. The first two questions fall under evaluations (belief system), whereas the third question falls under the planning part of reflective motivation. We assumed that if the respondent wants a swift transition, there is a high probability that they already started the mental process of assessing the impact of this decision on their household. Automatic motivation was assessed using four questions. The first question on whether they want to save their energy bill focused on their desires (want or need) or motives. The last three questions assessed the degree of influence by positive experiences from the (1) internet, (2) relatives and friends, and (3) neighbours. These questions were categorised under automatic motivation because the interactions may induce automatic imitation.

2.3 Behavioural change wheel and Behavioural Change Interventions (BCW)

The Behavioural Change Wheel (BCW) is a compilation of nineteen (19) behavioural change frameworks. None of these frameworks comprehensively characterised interventions or linked them to a systematic and holistic assessment of target behaviour. From these 19 frameworks, a three-tier wheel was developed. The hub of the wheel explains what behaviour needs to change, and comprises of three components (capability, opportunity, and motivation) and six sub-components (as explained in sub-section 2.2).

After detecting what needs to change, the middle layer, comprising of nine behavioural change intervention (BCI) functions, identifies the best approach to realise the change. The nine BCIs are education, persuasion, incentivisation, coercion, training, enablement, modelling, environmental restructuring, and restrictions. Education refers to an action aimed at increasing knowledge and understanding of the ongoing energy transition strategy, process, roles, responsibilities, and planned actions. Persuasion is the stimulation of energy transition actions or inducing feelings, whether positive or negative. Incentivisation creates an expectation of reward whereas coercion creates expectation of cost or punishment. Training occurs when there is an impartation of energy transition skills e.g., skills on the various energy sources or how to develop a home improvement plan that focuses on sustainable energy sources. Restriction is the use of rules to prohibit or reduce the engagement in competing behaviours. For instance, prohibiting future installation of natural gas infrastructure in newly constructed houses. Environmental restructuring occurs when the social or physical context is modified to encourage behaviour change. Modelling is when an example is presented for aspiration and imitation. Finally, enablement is when barriers to energy transition are reduced and means for successfully transitioning are increased. In Netherlands, the provision of energy coaches to support households in making complex energy transition decisions is a form of enablement.

The final layer contains seven policy categories: communication / marketing, legislation, regulation, fiscal measures, guidelines, environmental/ social planning, and service provision. Policy guidelines are not the focus of this paper.

The first layer of the BCW (COM-B model of behaviour) has two main functions. First, it ensures that when designing interventions, designers do not focus on one layer (individual or system). Second, COM-B model highlights the inter-dependence of behaviours to ensure the design of interventions that target a set of behaviours, instead of focusing on only one behaviour. The model treats behaviour as a system comprising of sets of inter-dependent behaviours. In the research context, transitioning to sustainable energy sources is interdependent on being able to raise resources to make the transition and understanding viable energy alternatives.

Each BCI is closely linked to the COM-B (see Table 1). Physical capability is increased through training and enablement whereas psychological capability is enhanced by training enablement and education. Both physical and social opportunity are increased by enablement, restriction, and environmental restructuring. Moreover, training enhances physical opportunity and modelling increases social opportunity. Automatic motivation is increased using all the interventions except for education and restriction. Reflective motivation is enhanced through education, persuasion, incentivisation and coercion.

Table 1. Matrix on linkages between COM-B and BCIs, source (Michie et al., 2015)

COM-B components / Intervention Functions	Education	Persuasion	Incentivisation	Coercion	Training	Restriction	Environmental Restructuring	Modelling	Enablement
Physical capability					■				■
Psychological capability	■				■				■
Physical opportunity					■	■	■		■
Social opportunity						■	■	■	■
Automatic motivation		■	■	■	■		■	■	■
Reflective motivation	■	■	■	■					

Applied, the COM-model provides insights in what should be altered to influence and change current behaviour. In addition, the linkages between the three COM-B components and the BCI provide a unique opportunity to propose interventions specifically targeted to influence the factors that lead to behavioural change, in a systemic manner.

3 Materials and Methods

The results of applying the COM-B model are sensitive to varied contexts, spaces, and time. Meaning, you might get different results when focusing on another subject matter, in another place in the same country or another country and at a different decade or century. Therefore, data and results should be understood in their context and the context described well. Also, researchers should understand what results are transferable to other contexts. Therefore, the materials and methods section start with a short case-study description, to provide sufficient context of the neighbourhood where we conducted the research.

3.1 Austerlitz case study

Austerlitz is a neighbourhood in Zeist Municipality, in the central province of Utrecht. It is a mixed neighbourhood (buildings with diverse years of construction) with a housing stock of 656 households in 2019 (see Fig. 2) and about 800 in 2021 (de gemeente Zeist, 2021a). The homes in Austerlitz are divided as follows: 39% are semi-detached houses (twee onder een kap); 31% are terraced houses (rijtjeshuis); 20% are free-standing houses (vrijstand); 5% are small flats (onder en boven) and 5% are diverse e.g., business premises (Austerlitz Duurzaam, 2019).

The neighbourhood has houses as old as 1805 and new houses that were constructed recently. In 2020, approximately 100 homes were constructed in Austerlitz, some with gas connection and others were natural gas-free (de gemeente Zeist, 2021b, de gemeente Zeist, 2021a). A majority (90%) of the homes are owned by individual households. There is a high level of risk for these households if renovations do not lead to a return on investment. There is a large diversity in real estate values (see WOZ[25] in Fig. 2) of the houses, depicting financial diversity and system complexity.

Austerlitz building density is low. Thus, a heat network (also known as district heating or "warmtenet") has little chance of success (de gemeente Zeist, 2021b). Moreover, the neighbourhood has exceptionally old houses and monuments, that require a higher temperature heat output. Thus, application of heat pumps is problematic, unless first, the insulation is improved. Insulation is expensive for detached houses; there are walls to be insulated on four sides. On the other hand, the energy bill is often high, that residents may consider changes that could reduce current costs. Also, insulation and ventilation make the homes more comfortable. Homeowners should decide whether to deploy far-reaching insulation and heat pumps or replace natural gas with green gas (hydrogen or biogas).

[25] WOZ refers to the Real Estate Valuation (WOZ) for the buildings. The municipality determines the WOZ value of a house based on an appraisal. Source of WOZ information: Belastingsamenwerking gemeenten & hoogheemraadscap Utrecht (BghU), 1-1-2017

Description	Numbers	Unit
Residents	1581	persons
Men	801	persons
Women	780	persons
Residents 0-15 years old	209	persons
Residents 15-25 years old	182	persons
Residents 25-45 years old	302	persons
Residents 45-65 years old	572	persons
Residents 65 and older	316	persons
# of Households	656	households
One person Households	162	households
Households without children (<18jaar)	333	households
Households with children (<18jaar)	161	households
Average # of persons per Household	2,4	persons
# of buildings	617	buildings
Average # of persons per Household	2,6	persons
Minimum WOZ value	55.000	euro
Maximum WOZ value	892.000	euro
Average WOZ value	319.170	euro
Number of WOZ objects to be used as a home	617	buildings
Owned by a natural person	532	addresses
Not owned by a natural person	92	addresses

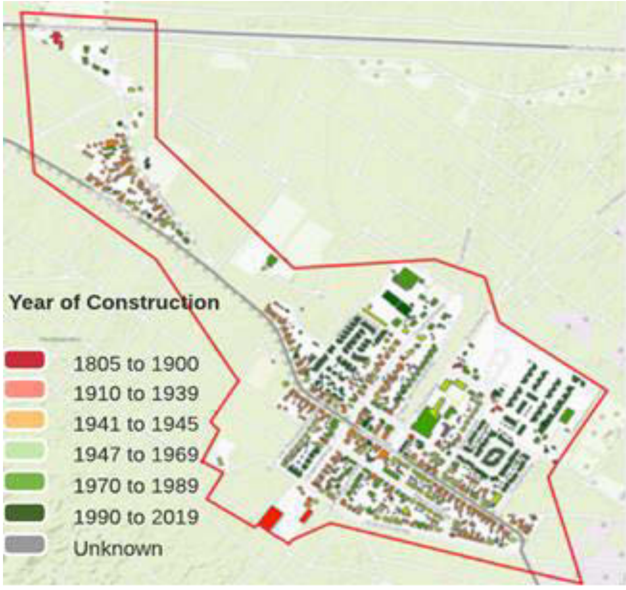


Fig. 2. Austerlitz Demographics and Map of houses (Source: Zeist municipality)

The Heat Transition Vision (de gemeente Zeist, 2021b) and the residents guide (de gemeente Zeist, 2021a) outline the following proposed renovations for the Austerlitz homeowners:

1. Insulation of cavity walls, roofs, and windows. The municipality informs the residents that hydrogen gas may not be cheaper than natural gas unless the house is well insulated to reduce drafts and prevent heat loss.
2. Floor insulation (recommended if there is a good crawl space).
3. Sustainable (demand-driven or with heat recovery) forms of ventilation.

The above-mentioned upgrades to an existing house so that it can meet contemporary or future conditions, this are referred to as retrofits. In this paper, the term retrofit is the equivalent to home renovation or restoration and not the same as routine repairs and maintenance.

3.2 Participants and procedures

3.2.1 Participants

Participants in the 19 kitchen interviews are homeowners (no tenants selected). Selection was based on housing types and participant's profile. Majority of the participants are male, above 45 years, and earn reasonable annual income (Fig. 3).

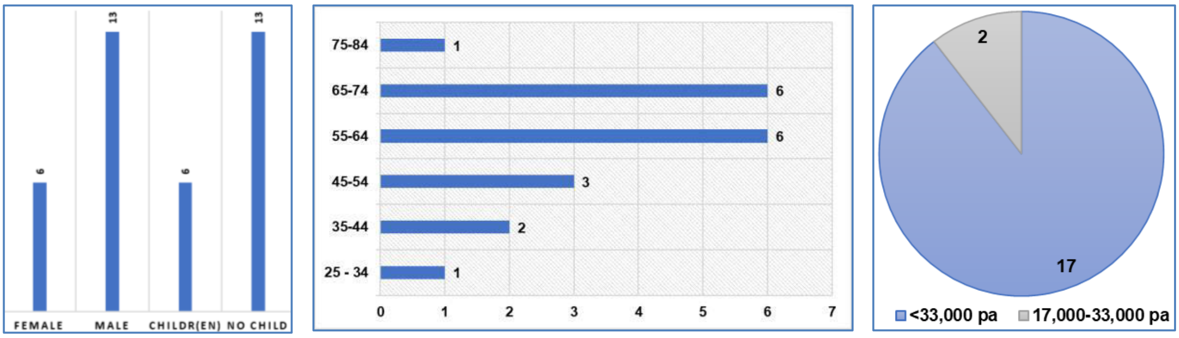


Fig. 3. Demographics (a) gender, houses with children, (b) age, and (c) income.

Most of the participants have no children living in the household. Six out of 19 participants do have children. Most participants are well educated and employed.

3.2.2 Procedure

The 19 one-hour interviews were conducted for ten days, in the participants kitchens, over a cup of coffee or tea, between the 4th to the 19th of March 2021. Participants were briefed for 10 minutes on the purpose of the interview, their role and how long it would take. Then the interviewers explained how the researchers will manage personal data and their consent was elicited.

Interviews were conducted in Dutch and the interviewers completed the answers in online forms. The questions asked during the structured interviews and the participant responses are available as supplementary material (Onencan and de Koning, 2022).

3.3 Measures

The structured interview consisted of 20 questions. The first part assessed the nature and extent of social influence. Follow-up questions probed participants perceptions concerning different energy sources. Then we assessed the capability, opportunity, motivation, and behaviour of each participant. Final questions gathered individual and household demographic data. The COM-B variables are presented in Table 2 and discussed below.

Table 2. COM-B variables to measure the intention – action gap

Construct	Variable	Type	Variable measurement
Capability	Physical capability	Interval: continuous	4 Point Likert scale
	Psychological capability	Interval: continuous	4 Point Likert scale
Opportunity	Physical opportunity	Interval: continuous	4 Point Likert scale
	Social opportunity	Interval: continuous	4 Point Likert scale
Motivation	Reflective motivation	Interval: continuous	4 Point Likert scale
	Automatic motivation	Interval: continuous	4 Point Likert scale
Behaviour	Homeowner behaviour	Nominal: dichotomous	0=No; 1=Yes

We used a 4-Point Likert scale for the subjective assessment of all the COM-B components, with options ranging from strongly disagree to strongly agree. We did not incorporate the neutral option because we wanted to get clear-cut responses on the participants perceptions. The current behaviour was assessed based on four elements, namely whether the participant has: (1) energy saving gadgets; (2) engaged in energy saving actions (e.g., switch of lights and sockets when not in use); (3) invested or applied for a loan or grant to start the transition process; and (3) a renovation plan that takes account of the transition.

4 Findings

In this section, we provide the results of the interviews on the participant's preferred energy source (section 4.1), current behaviour (section 4.1), capability (section 4.2), opportunity (section 4.3), and motivation (section 4.4).

4.1 Behaviour

4.1.1 Preferred Energy Source

The energy solutions, under consideration, for Austerlitz are: (a) green gas / hydrogen via the natural gas pipelines; (b) solutions with heat pumps (air heat pumps, or soil heat pumps with (shared) bottom loops), for all homes and buildings; and (c) a solar collector or PVT panel as a collective solution (de gemeente Zeist, 2021b, de gemeente Zeist, 2021a).

Based on the results of the kitchen interview, the generally preferred energy source is all electric. One of the participants stated that their preference will vary "*depending on energy tax, investments, energy prices*", (external opportunities). The main challenge people see with an all-electric energy source, is that it is too expensive, the temperature (not warm enough), and reliability. Homeowners fear that electricity might be depleted during winter season, with no contingency plan or sufficient storage. Hydrogen is the second preferred option because it may lower their current bills and it is considered the highest temperature source for heating. According to the 19 interview responses, hybrid solutions are the most reliable, their warmth is at acceptable levels, and they are perceived not to be very expensive. The main challenge with hybrid systems is safety. However, if the municipality is considering Hydrogen as a viable option, green-gas acceptance levels are considerable. One participant added that safety is not an issue because "*Everything is equally dangerous if used incorrectly*." The main issue that the municipality may need to address is the expense of replacing natural gas with hydrogen.

4.1. 2 Current Behavioural Actions

All possible energy solutions require complementary home retrofits to ensure that the house is safe, warm, and comfortable. Figure 4 contains responses to the interview question: Have you already done any of the following to improve your home?

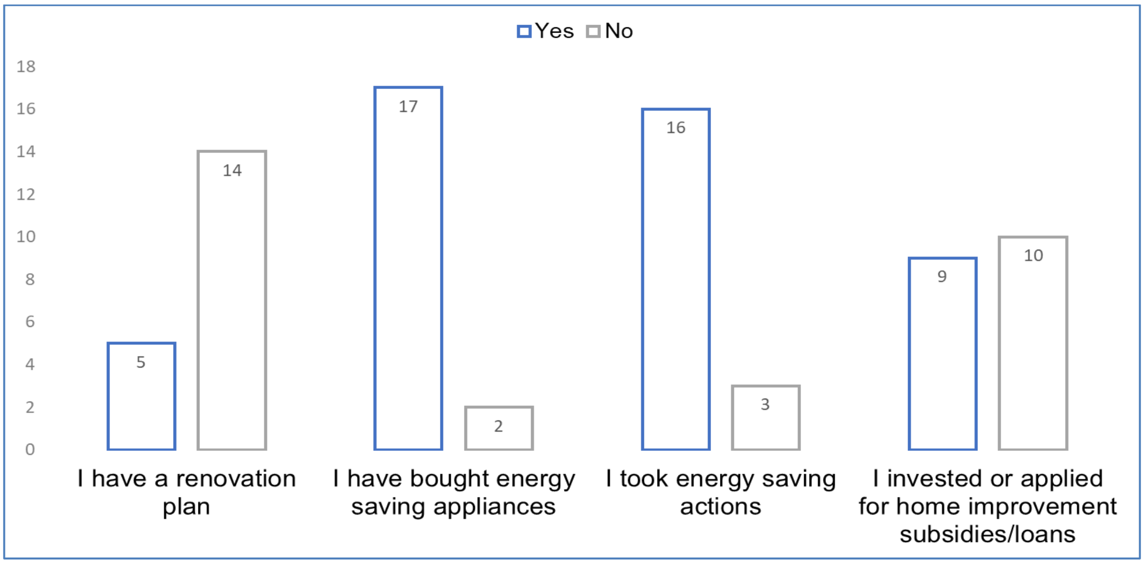


Fig. 4. Homeowners' current behaviour

The most practiced (89%) behaviour is purchasing sustainable appliances (LED lamps, refrigerator with high energy label, water-saving shower head), closely followed (84%) by changing energy use behaviour (thermostat lower, lights off, etc.). Then investing or applying for grants or loans to improve their home and finally, the least action (26%) was developing a home renovation plan, e.g., to upgrade heating, ventilation, and air conditioning equipment.

The first two highest responses (energy saving gadgets and actions) indicate that the participants are highly engaged and motivated for short-term energy saving. However, the main challenge is their approach to long-term change (e.g., developing a home renovation plan, consistent with ongoing energy transition processes); it is piecemeal, and not systemic.

4.2 Capability

The questions related to capability were divided into two parts, physical capability mainly focusing on homeowner's skills needed to be able to make the transition (Fig. 5.) and psychological capability that assesses homeowner's understanding of the goal and responsibilities of various energy transition actors (Fig. 6.).

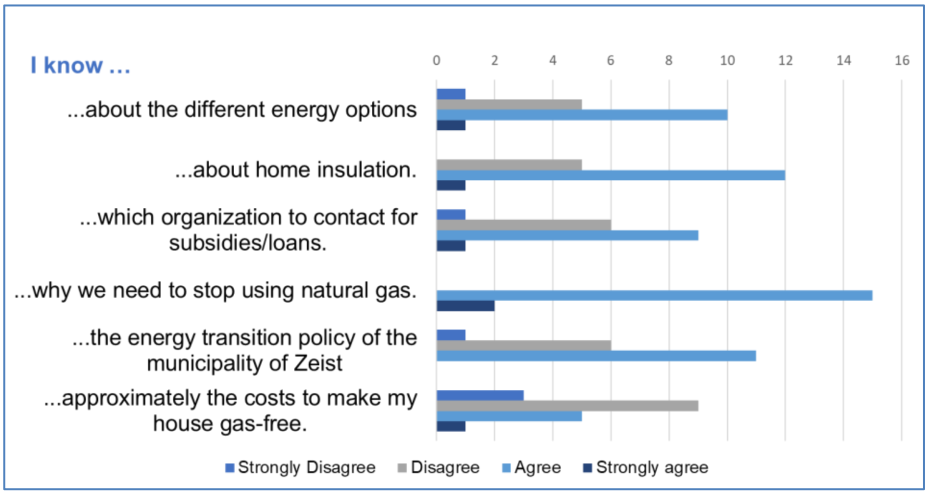


Fig. 5. Homeowner's skills (physical capability)

Analysis of the participant responses to the capability question indicate higher levels of psychological capability compared to physical capability (Fig. 5 and 6).

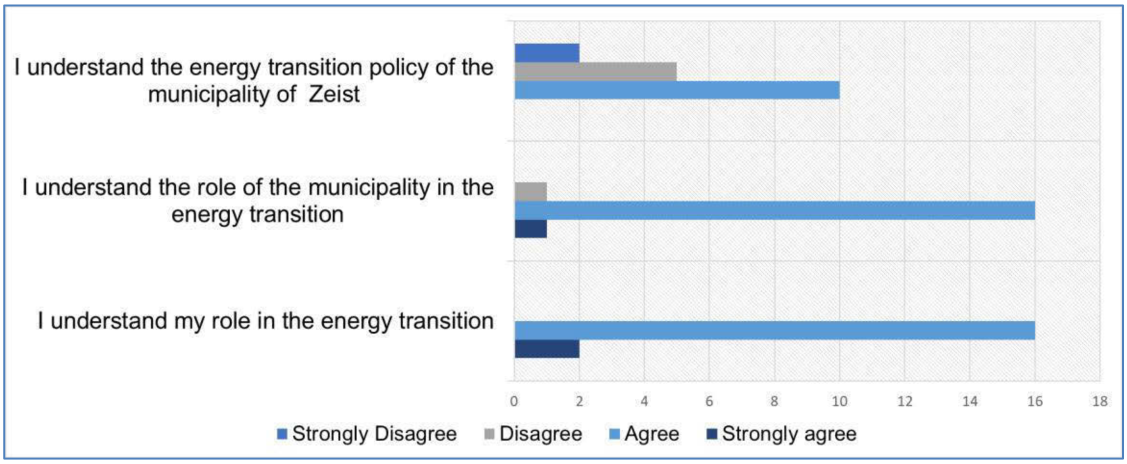


Fig. 5. Homeowner's understanding of the transition (psychological capability)

Every participant knows why the Netherlands should stop using natural gas. More than half of the participants agree that they know: (1) different energy sources; (2) how to insulate their homes; (3) what organizations to contact and (4) the energy transition policy for Zeist municipality. The homeowners do not have sufficient knowledge on the approximate costs of making their house gas-free, which indicates a lower level of perceived behavioural control (Fig. 5.). The results in Figure 6 indicate that the role of the municipality and individual household's roles are rather well understood, but less so the energy transition policy.

4.3 Opportunity

Opportunity questions (Fig. 7) were divided into two parts: physical (influenced by the environment) and social (influenced by interpersonal relations). The first three questions focus on physical opportunity while the last two on social opportunity. Social opportunity is stronger than physical opportunity because most people know of their neighbours who have initiated the energy transition process and there is positive social influence on electric / induction cooking in the neighbourhood.

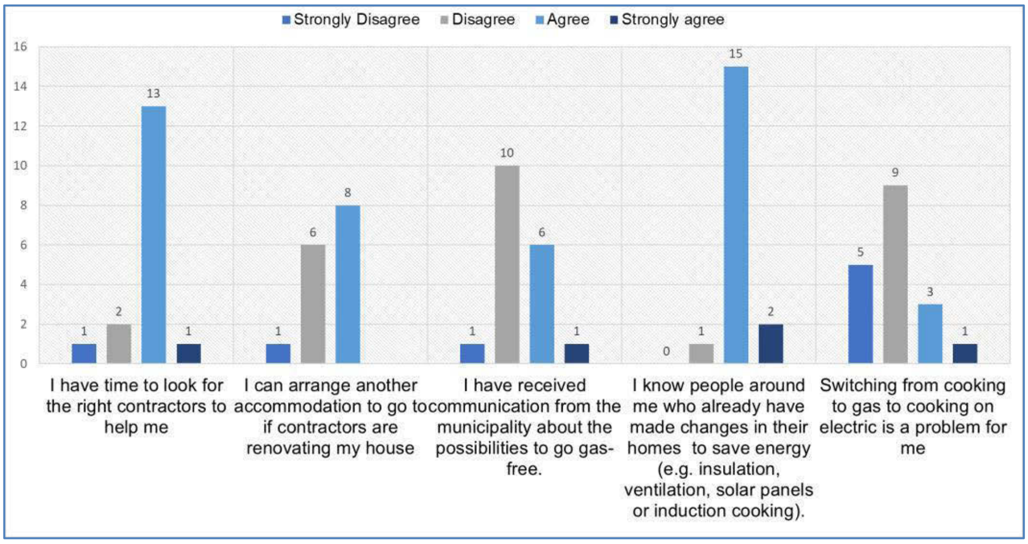


Fig. 7. Individual homeowners' opportunity

The interview data shows that the time it takes to look for a contractor is not a real issue for many people. However, arranging alternative accommodation might be more problematic. About half of the participants confirm that they have not received communication from Zeist municipality about the possibilities of becoming gas-free. However, many people indicate that they know neighbours who have energy transition expertise, these people are potentially strong influencers of the motivation of other individuals (Fig. 7). Finally, moving towards gas-free cooking is not perceived as problematic by most (Fig. 7).

4.4 Motivation

The results on the three factors measuring reflective motivation were diverse (see Fig. 8). Most of the interviewees believe that transitioning away from natural gas is good for the environment but the thoughts on if the neighbourhood should transition are less positive. Moreover, many people are convinced that home retrofits or alternative energy solutions will cost them more money than they spend now. These results show that money in terms of costs of energy transition contributes to uncertainty (see Fig. 5, responses to the last question).

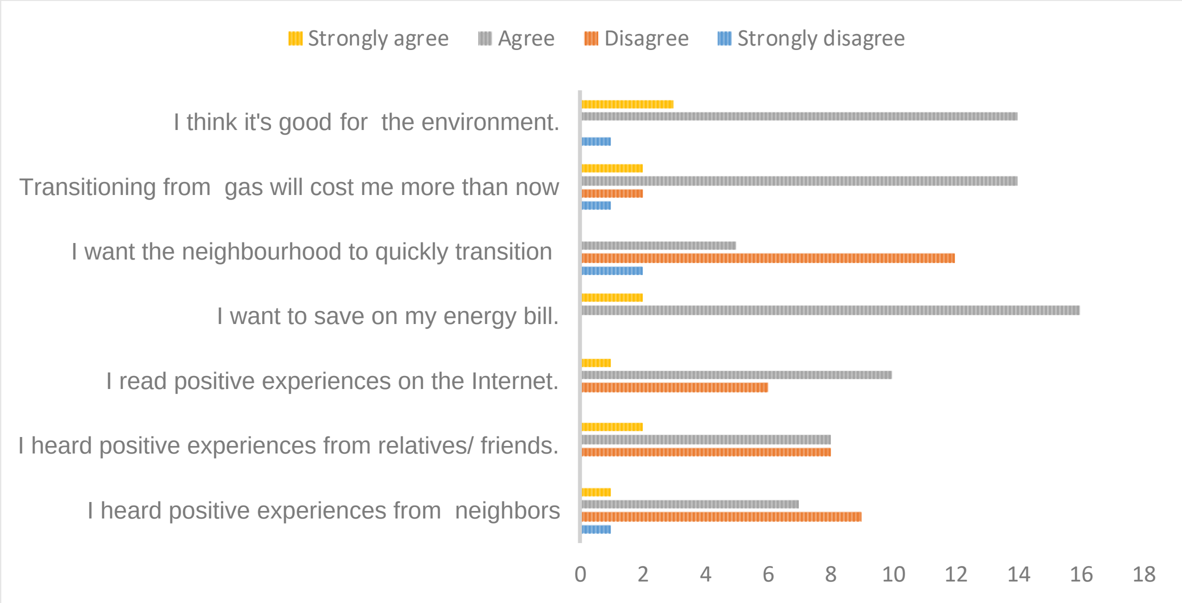


Fig. 8. Motivation to transition to renewable energy sources

Under automatic motivation, people are motivated to transition to make savings on their energy bill. Reduced energy bills are a positive desire (whether a want or need) and clear motive for the desired behaviour. According to the other automatic motivation results, the positive social influence from neighbours, relatives and friends is not compelling. The percentage of people who agree and disagree are comparable. However, the interviews and case study material do show that there is a strong social network in the neighbourhood. But it is not clear from the results whether people have not heard any positive experiences because they do not exist or because the negative experiences overshadow the positive. Interestingly, social influence through internet seems to play a slightly larger role in positive messages than face to face social influence for the participants.

5 Discussion & Conclusions

The paper answers two research questions: (1) what source of energy transition behaviour (capability, opportunity, and motivation) could activate systemic behavioural change at the household level? (2) what BCIs best address the identified system of behaviours? The results of both questions are discussed in Subsections 5.1 and 5.2. Subsection 5.1 discusses specific behaviour that needs to change and proposed interventions to enhance resident capability, opportunity, and motivation for Zeist municipality and similar organisations. Subsection 5.2 explains the scientific contribution of this paper in reference to the behaviour that needs to change and its subsequent interventions. In section 5.3 we discuss how we mitigated the research limitations we faced.

5.1 Contribution to Practice

Results indicate that currently Austerlitz residents generally have a positive attitude towards the energy transition but are mostly focused on short-term solutions and the monetary costs and benefits of the energy transition. Most of the interviewees believe that transitioning away from natural gas is good for the environment but they are not always convinced it will lead to monetary benefits for themselves. Therefore, future interventions, in Austerlitz and similar local authorities, should also target other facets of reflective motivation (goals and intentions). Target interventions could be a combination of education, persuasion, coercion (e.g., regulations, guidelines, or fiscal measures to deter gas usage) and incentivisation (e.g., tax free benefits, grants, subsidies, loans, free advisory services, and free gadgets) (Michie et al., 2015). Interventions should focus on enhancing homeowner's belief that action towards the energy transition is beneficial for them, to motivate them to incorporate it in their long-term retrofit plans. Also, interventions should enhance homeowners' motivation for long-term engagement in energy transition, not only as key players, but as main drivers of change. Education and persuasive interventions may also consist of reframing issues, to change homeowners understanding of the behaviour that needs to change. Automatic motivation of saving the energy bill and reducing the energy transition costs is a key concern and one of the primary drivers of behavioural change. Moreover, the positive social influence from neighbours, relatives and friends needs to be tapped to bridge the intention-action gap. To address automatic motivation, the municipalities need to prepare a combination of interventions that persuade, incentivise, coerce, train, enable, structure the environment and model the desired behaviour so that automatic imitation can be induced (Michie et al., 2015, Michie et al., 2011). These interventions should focus on a system of behaviours as opposed to one behaviour (Michie et al., 2015). Since money is a (de)motivating factor, the central government and municipalities should consider the option of shifting a large bulk of the energy transition project and advisory related budget allocations towards supporting households that do not have the resources to implement energy transition (incentivisation). In addition, households should be enabled, and the policy environment restructured to facilitate more opportunities and access to tax benefits, tax reliefs, energy transition loans, and free or discounted energy gadgets.

Related to that, the opportunity factors should also be enhanced towards connecting small steps (buying energy saving appliances for example) to more and more elaborate steps. The behaviour that municipalities should facilitate is a shift, by homeowners, from piecemeal short-term actions, toward long-term oriented, systemic retrofits. Municipalities should especially focus on physical opportunity because it was weaker than social opportunity. This means that there should be a strong focus on providing training, restrictions, environmental restructuring to facilitate energy transition and enablement (Michie et al., 2015). As an intermediate measure, while Austerlitz is still waiting for a collective decision on the preferred energy source(s), the municipality could focus on promoting simpler, quick, win-win solutions like induction heating, but clearly linked to longer-term interventions. Showing these quick steps as part of a longer process and the gains it leads to, can enhance the overall belief in the benefits for the individual (motivation). This should lead to a certain buy-in and spillover effect towards other behaviours, in the long term. Next to that, working on providing ways to mitigate inconvenience during retrofits (long-term solutions) should open-up opportunities for people to make home renovation plans and execute them. Also, to increase social capability amongst relatives, friends and neighbours (which was lower than internet), the municipality should incorporate modelling as one of its interventions for changing the current behaviour (Michie et al., 2015). One effective way to use modelling is through interactive gaming simulation where energy networks for every household can be built and strengthened in both the virtual and physical environment (Barrios-O'Neill and Hook, 2016). Last, since the focus of many people is on the monetary aspects, the opportunities offered should clearly address the financial aspects of energy transition.

Under capability fall the psychological and physical aspects of being able to engage in a behaviour. This means the knowledge needed, but also the possibility for someone to engage in actions and routines that go with the energy transitions actions. What we see, and what many other studies before us found, is that there is an intention-action gap. Many people believe that transitioning away from natural gas is a good thing. People now, more than ever, have the intention to act (even more so with the current situation of the gas prices increasing and the instability due to the war in Ukraine, though our study was done prior to this). However, people often do not know how. As a municipality it is crucial to provide this information. We acknowledge the limitations of information provision; alone information can never start a transition. However, we did find a perceived lack of information provision from the municipality so far. Half of the people indicated that they did not receive information from the municipality, and even less so say that they understand the policy of the municipality.

Participant responses to the capability question indicated higher levels of psychological capability compared to physical capability, which means that the target interventions should focus less on education and more on training and enablement (Michie et al., 2015). Education increases knowledge or understanding, whereas training moves a step further and imparts specific skills. Enablement involves tailored support (e.g., provision of an energy coach to guide households throughout the transition process) to increase the household means and reduce capability barriers (Michie et al., 2015, Michie et al., 2011). The results show that the monetary aspect for the capability component is uncertain. People do not know exactly what the costs will be. Also, the costs and benefits of going all-electric is not clear to people. Since all the houses are built in different years, and have different energy, insulation and ventilation needs, a tailored approach (enablement) is highly recommended, where energy coaches are assigned to households and paid by the municipality. These coaches, though specialised in alternative energy solutions, should also be able to: calculate the costs of the transition based on each household, connect households to reputable contractors, identify good quality products (e.g., solar panels), and have knowledge on financial services for households (grants, loan facilities and subsidies). These coaches or the municipality should also train households through imparting critical energy transition skills (e.g., a complete training on solar power that assesses benefits, viability, tax credits, other incentives, installation, costs, and maintenance). Moreover, municipalities should consider one-stop-shops where homeowners access relevant energy transition information, easily and fast. The municipality should send out regular communication, even when the future is uncertain, and the information on the possible energy solutions is not clear-cut. Future information provision should also address the capabilities towards higher perceived behavioural control. These may include having 'show' or 'display' houses, installing an energy neighbourhood exchange network, and highlighting inspirational stories of residents that have transitioned on the municipality website.

In conclusion, we suggest that municipalities connect their energy transition plans to current renovation plans of their residents, to comply with current beliefs and desires of cost saving, comfort, and aesthetics. Similarly, small steps should be clearly part of a long-term plan, easy next steps should be offered, and comprehensible stepwise action plans developed, starting small but leading to larger changes in the future. More transparency in the monetary aspects, financial enablement and support in inconvenience during retrofits should increase the opportunity and ability for people to act. Last, interventions should enhance homeowners' belief that energy transition is an intrinsic part of their long-term home renovation plans, to motivate them to drive the energy transition process. This may enhance homeowners' long-term engagement in energy transition, as the main drivers of change.

5.2 Contribution to Science

According to West and Michie (2020), there are two major actions that need to take place when applying the COM-B model: (1) capability and opportunity are the gates that "need to be open for motivation to generate the behaviour," and (2) there should be a spillover effect (negative or positive) between behaviour and the three sources of behaviour (capability, opportunity, and motivation). We will discuss these two effects, in reference to the results in this paper.

First question is: are the gates open for households to be motivated? The responses indicate that the doors are not widely open. Figure 5 shows that practical things like knowing the cost of the transition, and information on subsidies and loans is lacking but more general information like why they should stop using natural gas is readily available. This shows that information provision needs to be more specific and practical, oriented towards action. However, information provision is not enough to ‘open the gates’ and address systemic problems (Karvonen, 2013). The static nature of knowing limits its ability to lead to systemic changes - knowledge alone is not enough. Interventions should focus especially on enhancing household capabilities through increased understanding. Understanding is a social process, which occurs through active learning (Metcalfe and Ramlogan, 2005, Onencan and Van de Walle, 2018, Onencan, 2019). Active learning enables the homeowners to actively engage with the municipality, contractors, banks, financial institutions and other providers, in the process of constructing knowledge and sense making (Karvonen, 2013). Shroff et al. explain that active learning “*gives learners the opportunity to utilize their cognitive and higher-order skills and strategies by creating meaning from their experiences and the environment and from thereon, constructing their own knowledge and understanding* (Shroff et al., 2021).” To accelerate the energy transition, the focus should be on interventions that increase understanding of practical aspects of the transition. According to Michie et al. (2015), such interventions may include: modelling (demonstration of target behaviour), participatory environmental restructuring and participatory enablement of energy communities.

Second question is: do current behavioural actions, as presented in subsection 4.1.2, lead to positive spillover effects. Behavioural spillover theory is suggested when a set of behavioural changes are expected, leading to wider lifestyle adjustments. The theory proposes that engagement in one voluntary energy transition action could catalyse residents to make “wider lifestyle shifts beyond piecemeal” adjustments (Nash et al., 2019). The first two responses (energy saving gadgets and actions) indicate that the participants are highly motivated to change the current energy environment. However, the main challenge is their approach to change; it is piecemeal, and not systemic towards the more effective retrofits. Based on the responses, we assume that past interventions focused solely on technical issues (energy efficiency and carbon reduction) and barely tapped into other factors that influence people to make the change (aesthetics, safety, convenience, and comfort). Research indicates that to achieve widespread retrofit, homeowners should focus less on piecemeal technical solutions and more towards a systemic, long-term oriented approach that combine social and technical aspects (Karvonen, 2013, Karvonen, 2018, Kieft et al., 2020, De Feijter et al., 2021). Long-term orientation places the renovation plan with the supporting finances at the forefront and the energy saving gadgets at the rear. Identifying the behaviour that would have a multiplier effect is imperative for the energy transition.

Last, the research concludes that there is untapped potential in using the COM-B model and the behavioural spillover theory “as a means of catalysing wider sustainable lifestyle shifts” (Nash et al., 2019). The COM-B model assumes that the target behaviour is known, which is not true, in most complex cases. The target goal of transitioning away from natural gas is known, but not to what exactly, there are still different options to choose from. Also, the initial target behaviour that can lead to energy transition spillover actions was not known. Moreover, it was not known what interventions would lead to greater impact with less input.

In conclusion, there are different levels of systemic change proposed with the iceberg model (events, patterns/trends/ underlying structures, and mental models). The last level focusing on mental models seeks to transform mindsets. Taking this into consideration, this paper analyses the deepest level of these types of transitions using a transparent COM-B model of behaviour and nine intervention functions. We identify viable interventions that may lead to mindset changes combined with behaviour analysis to better understand what can be done to bridge the intention-action gap. The research contributes to the identified research intention-action gap, by identifying key interventions that should be enhanced to ‘open the gate’ for behavioural change and motivate or activate households to voluntarily engage in energy transition, in a long-term, sustainable, and systemic manner. This general idea we believe could be replicated in different contexts and challenges.

5.3 Study Limitations

We identified the main study limitations early in the research and sought four ways to mitigate them. First, Zeist municipality case study and Austerlitz neighbourhood in particular were not selected at random, and this may lead to selection bias (Maesschalck, 2016, Leys, 2016). This limitation was minimised by ensuring that we document all the characteristics of the case study, so that when other researchers seek to replicate the study, they understand the context within which it was applied (Leys, 2016). Second, interviewing 19 respondents in a neighbourhood with 656 households, would lead to under-coverage and exclusion bias (Sala and Lillini, 2017). To address this, we worked closely with the Zeist municipality and representatives of the neighbourhood to ensure that we selected households that represent the entire neighbourhood in terms of housing types, level of transition and demographics. Third, the selected case study approach with the use of structured interviews, in general, has limited external validity (Maesschalck, 2016). To address this gap we extensively describe the case study under the materials and methods section so that when researchers seek to replicate the study they should make this decision on a case-by-case basis (Ruddin, 2006, Firestone, 1993). Finally, to increase replicability and internal validity, we used a structured approach of asking the interview questions through a questionnaire (with a few open questions), which is available as supplementary materials together with the dataset on the 4TU.ResearchData portal under DOI: 10.4121/19709053.

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References

Ajzen, I. 1991. The theory of planned behavior. *Organizational behavior and human decision processes,* 50**,** 179-211.

Austerlitz Duurzaam 2019. Duurzaam Warmte Austerlitz. Austerlitz Duurzaam, Zeist, the Netherlands.

Barrios-O'Neill, D. & Hook, A. 2016. Future energy networks and the role of interactive gaming as simulation. *Futures,* 81**,** 119-129.

Bem, D. J. 1972. Self-perception theory. *Advances in experimental social psychology.* Elsevier.

Broers, W., Vasseur, V., Kemp, R., Abujidi, N. & Vroon, Z. 2019. Decided or divided? An empirical analysis of the decision-making process of Dutch homeowners for energy renovation measures. *Energy Research & Social Science,* 58**,** 101284.

Cialdini, R. B. & Goldstein, N. J. 2004. Social influence: Compliance and conformity. *Annu. Rev. Psychol.,* 55**,** 591-621.

De Feijter, F. J., Van Vliet, B. J. & Spaargaren, G. 2021. Energy efficient housing through organized interactions? Conceptualizing the roles of householders and providers in housing retrofitting in the Netherlands and China. *Housing, Theory and Society,* 38**,** 21-41.

de gemeente Zeist 2021a. Handreiking ‘stapsgewijs naar aardgasvrij’: Wat kunnen huiseigenaren in Austerlitz, Bosch en Duin, Den Dolder, Huis ter Heide en Zeist nú al doen om hun huis in stappen voor te bereiden op een aardgasvrije toekomst? *In:* MILLEU, E. E. (ed.). Zeist, the Netherlands: de gemeente Zeist,.

de gemeente Zeist 2021b. Transitievisie Warmte Zeist 2021: Naar een duurzame manier van verwarmen. *In:* MILLEU, E. E. (ed.). Zeist, the Netherlands: de gemeente Zeist,.

Dekker, P., den Ridder, J., van Houwelingen, P. & van den Broek, A. 2016. *Burgerperspectieven 2016|4,* Den Haag, Sociaal en Cultureel Planbureau.

Dubois, G., Sovacool, B., Aall, C., Nilsson, M., Barbier, C., Herrmann, A., Bruyère, S., Andersson, C., Skold, B. & Nadaud, F. 2019. It starts at home? Climate policies targeting household consumption and behavioral decisions are key to low-carbon futures. *Energy Research & Social Science,* 52**,** 144-158.

Ebrahimigharehbaghi, S., Filippidou, F., van den Brom, P. & Visscher, H. J. Analysing the energy efficiency renovation rates in the Dutch residential sector. E3S Web of Conferences, 2019. EDP Sciences, 03019.

Filippidou, F., Nieboer, N. & Visscher, H. 2017. Are we moving fast enough? The energy renovation rate of the Dutch non-profit housing using the national energy labelling database. *Energy Policy,* 109**,** 488-498.

Firestone, W. A. 1993. Alternative arguments for generalizing from data as applied to qualitative research. *Educational researcher,* 22**,** 16-23.

Fishbein, M. & Ajzen, I. 1977. Belief, attitude, intention, and behavior: An introduction to theory and research. *Philosophy and Rhetoric,* 10.

Gilal, F. G., Zhang, J., Paul, J. & Gilal, N. G. 2019. The role of self-determination theory in marketing science: An integrative review and agenda for research. *European Management Journal,* 37**,** 29-44.

Hagger, M., Chatzisarantis, N. & Biddle, S. 2002. A meta-analytic review of the theories of reasoned action and planned behavior in physical activity: Predictive validity and the contribution of additional variables. *Journal of sport & exercise psychology*.

Hertwich, E. G. & Peters, G. P. 2009. Carbon footprint of nations: a global, trade-linked analysis. *Environmental science & technology,* 43**,** 6414-6420.

Jansma, S. R., Gosselt, J. F. & de Jong, M. D. 2020. Kissing natural gas goodbye? Homeowner versus tenant perceptions of the transition towards sustainable heat in the Netherlands. *Energy Research & Social Science,* 69**,** 101694.

Karvonen, A. 2013. Towards systemic domestic retrofit: a social practices approach. *Building Research & Information,* 41**,** 563-574.

Karvonen, A. 2018. *Community housing retrofit in the UK and the civics of energy consumption*, John Wiley and Sons.

Kieft, A., Harmsen, R. & Hekkert, M. P. 2020. Problems, solutions, and institutional logics: Insights from Dutch domestic energy-efficiency retrofits. *Energy Research & Social Science,* 60**,** 101315.

Klaassen, R. & Patel, M. 2013. District heating in the Netherlands today: A techno-economic assessment for NGCC-CHP (Natural Gas Combined Cycle combined heat and power). *Energy,* 54**,** 63-73.

Leys, M., Zaitch, D., & Decorte, T. 2016. De gevalstudie. *In:* ZAITCH, T. D. D. (ed.) *Kwalitatieve methoden en technieken in de criminologie.* Leuven, België: Acco.

Liebe, U., Preisendörfer, P. & Meyerhoff, J. 2011. To pay or not to pay: Competing theories to explain individuals' willingness to pay for public environmental goods. *Environment and Behavior,* 43**,** 106-130.

Ligterink, J., Kleijwegt, J. & van de Rijt, A. 2019. De mobiliseerbaarheid van huurflatbewoners voor de energietransitie. *Mens en maatschappij,* 94**,** 91-115.

Maesschalck, J. 2016. Methodologische kwaliteit in het kwalitatief onderzoek. *In:* DECORTE, T. & ZAITCH, D. (eds.) *Kwalitatieve Methoden En Technieken in De Criminologie (Tweede Editie).* 2 ed. Leuven, Belgium: Acco.

Metcalfe, J. S. & Ramlogan, R. 2005. Limits to the economy of knowledge and knowledge of the economy. *Futures,* 37**,** 655-674.

Michie, S., Atkins, L. & West, R. 2015. The behaviour change wheel: a guide to designing interventions. *Great Britain: Silverback Publishing*.

Michie, S., Van Stralen, M. M. & West, R. 2011. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implementation science,* 6**,** 42.

Ministerie van Economische Zaken 2016. Energierapport. Transitie naar duurzaam. *The Hague.*

Ministry van Economische Zaken en Klimaat 2019. Klimaatakkoord. *In:* KLIMAAT (ed.). Den Hague: Ministry van Economische Zaken en Klimaat,.

Nash, N., Whitmarsh, L., Capstick, S., Hargreaves, T., Poortinga, W., Thomas, G., Sautkina, E. & Xenias, D. 2017. Climate-relevant behavioral spillover and the potential contribution of social practice theory. *Wiley Interdisciplinary Reviews: Climate Change,* 8**,** e481.

Nash, N., Whitmarsh, L., Capstick, S., Thøgersen, J., Gouveia, V., de Carvalho Rodrigues Araújo, R., Harder, M. K., Wang, X. & Liu, Y. 2019. Reflecting on behavioral spillover in context: How do behavioral motivations and awareness catalyze other environmentally responsible actions in Brazil, China, and Denmark? *Frontiers in psychology*, 788.

Onencan, A. 2019. Institutional Change through Social Learning: Climate Change Policy Gaming in Kenya.

Onencan, A. M. & de Koning, J. I. J. C. 2022. The COM-B Model Dataset and Questionnaire. *In:* ONENCAN, A. M. (ed.). The Netherlands: 4TU.ResearchData.

Onencan, A. M. & Van de Walle, B. 2018. From paris agreement to action: Enhancing climate change familiarity and situation awareness. *Sustainability,* 10, 1929.

Raad voor de Leefomgeving en Infrastructuur. 2017. Energietransitie en leefomgeving. Kennisnotitie. Available: https://www.rli.nl/sites/default/files/kennisnotitie_energietransitie_en_leefomgeving_def.pdf [Accessed 30 May 2022].

Raven, R. & Verbong, G. 2007. Multi-regime interactions in the Dutch energy sector: the case of combined heat and power technologies in the Netherlands 1970–2000. *Technology Analysis & Strategic Management,* 19, 491-507.

Ruddin, L. P. 2006. You can generalize stupid! Social scientists, Bent Flyvbjerg, and case study methodology. *Qualitative inquiry,* 12, 797-812.

Sahu, A. K., Padhy, R. & Dhir, A. 2020. Envisioning the future of behavioral decision-making: A systematic literature review of behavioral reasoning theory. *Australasian Marketing Journal (AMJ),* 28, 145-159.

Sala, E. & Lillini, R. 2017. Undercoverage Bias in telephone surveys in Europe: the Italian case. *International Journal of Public Opinion Research,* 29, 133-156.

Shroff, R. H., Ting, F. S., Lam, W. H., Cecot, T., Yang, J. & Chan, L. K. 2021. Conceptualization, Development and Validation of an Instrument to Measure Learners' Perceptions of Their Active Learning Strategies within an Active Learning Context. *International Journal of Educational Methodology,* 7, 201-223.

Steenbekkers, A. & Scholte, S. 2019. Onder de pannen zonder gas? Woningeigenaren en hun afwegingen voor aardgasvrije alternatieven. *In:* (SCP), S. E. C. P. (ed.). Den Haag, the Netherlands: Sociaal en Cultureel Planbureau (SCP).

Steg, L., Perlaviciute, G., Sovacool, B. K., Bonaiuto, M., Diekmann, A., Filippini, M., Hindriks, F., Bergstad, C. J., Matthies, E. & Matti, S. 2021. A Research agenda to better understand the human dimensions of energy transitions. *Frontiers in psychology*, 2421.

Thøgersen, J. & Schrader, U. 2012. From knowledge to action—new paths towards sustainable consumption. *Journal of Consumer Policy,* 35, 1-5.

Verbong, G. P. J. & Schippers, J. L. 2000. De revolutie van Slochteren – de ombouwoperatie. In: A. de la Bruhèze, H. Lintsen, A. Rip en J. Schot (red.). (p.). *In:* A.A.A. DE LA BRUHÈZE, H. W. L., ARIE RIP, AND J.W. SCHOT (ed.) *Techniek in Nederland in de twintigste eeuw. Deel 2. Delfstoffen, energie, chemie.* Den Haag: dbnl.

Vermeir, I. & Verbeke, W. 2006. Sustainable food consumption: Exploring the consumer "attitude–behavioral intention" gap. *Journal of Agricultural and Environmental ethics,* 19**,** 169-194.

West, R. & Michie, S. 2019. UBC Briefing 9: A brief description of the PRIME Theory of Human Motivation. *Unlocking Behaviour Change* [Online]. Available: https://www.studocu.com/hu/document/pecsi-tudomanyegyetem/oral-medicine/prime-thoery-and-revealed-evidence-with/17911449 [Accessed 3 May 2022].

West, R. & Michie, S. 2020. A brief introduction to the COM-B Model of behaviour and the PRIME Theory of motivation [v1]. *Qeios*.

Integrating Inclusion into Technologies – Practical Insights from two case studies in VR-Technology and E-Mobility

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Abstract
For most of us today, using technologies often is not optional anymore. However, inclusivity and a user-centred approach are still not the default in technology development. There remains a lot to learn on how to apply technologies to different contexts and for diverse user groups. Using two examples of FEMtech research projects (VR4Care on the use of virtual reality in nursing homes and FEMCharge on the development of charging infrastructure for e-cars), we want to give practical insights into two research projects which specifically tried to consider sex and gender in an intersectional way when developing new technologies. In both, we were able to identify relevant insights for the future development of technologies with approaches geared towards more inclusion using focus groups, usability tests, interviews and intersectional analysis of the obtained data. In these two research processes, we were able to witness that while looking at sex and gender as a variable remained relevant, other dimensions of diversity and/or their intersection also caused large disparities. It therefore was elementary to take these into account, as they often turned out to carry more weight than sex or gender. We concluded that it is not enough to consider gender as an isolated variable, but that a user-centred approach needs to be an intersectional approach. Research practice shows us, that there are many limitations and challenges associated with these kinds of research processes. In the conclusion, we therefore also outline our thoughts on the practical challenges we encountered.

1 Introduction

We are not alone in the belief that technology should work equally well for everyone and treat everyone the same. In reality however, this is often not the case. Speech-recognition software tends to work better for male than female voices. Face recognition works best for white males and worst for black female-read persons. Usability tests, voice-activated virtual assistants like Alexa and Siri, as well as video games and translation software often feature gendered aspects, such as voice, looks or learned behaviours, which reinforce gender norms and stereotypes (for more information and examples see https://genderedinnovations.stanford.edu/Criado Perez 2019).

One of the reasons for this is so-called "I-methodology". With “I-methodology" developmental processes are described in which researchers, designers and engineers see themselves as typical users and develop products based on their own peer-groups needs (see Akrich 1995; Oudshroon et al. 2004). This is problematic because researchers have a special "insider relationship" to technology, which distinguishes their worldview from that of other users. This is due to the fact, that a majority of staff in departments for technological development are white male employees, who are at risk to have a biased perspective of the world and technology (Eurostat 2021; Franklin 2021). As a result, the worldviews and circumstances of females, gender-diverse, disabled, seniors and BIPoCs (and their intersections) are often not represented and considered. From a methodological point of view, it is therefore obvious that so-called "I-methodology" can lead to the development of technology that is not ideal for a diverse range of target groups. One way of tackling this, is increasing the diversity in technical development teams. However, this alone is not enough, as developers tend to have a very specific relationship with technology. Therefore, "user-centered technology development" or "user-centered design" is necessary to ensure the highest possible usability for the broadest possible user group. This is achieved by placing the future users of a product at the centre of the development process (Schraudner et al. 2013).

User orientation is mainly dealt with in two different contexts or discourses:

(1) In industry and business, there is a long tradition, e.g. in the form of usability engineering in the IT sector or the usability of medical technology products in the form of standards (cf. Sarodnigg/Brau 2011; Backhaus 2009; Maramba et al. 2019; Curcio et al. 2019).

(2) As Londa Schiebinger (2008) describes, gender and diversity research has evolved from the question of the representation of women in research to the question of taking diversity dimensions into account in research. "Fixing the knowledge" is now also implemented in funding guidelines of the European Commission (2014; 2021), while gender and diversity dimensions are also integrated into scientific and technical research projects in Austria, often in the form of an increased user orientation (BMBWF/BMVIT/BMDW 2019). While ‘gender blindness’ often leads to neglecting relevant social dimensions, gender awareness can open up research for other relevant social parameters beyond gender. Including a gender perspective can thus increase the quality of research and its relevance for society (EIGE 2021).

While the interest in usability has increased in agile software development, difficulties remain in applying methods to synthesise these research findings, as there is no agreement on how user-centred methods should be incorporated (Curcio et al. 2019). According to Rommes (2014) participatory designs that more closely involve users have now been introduced into the development process in the IT-sector. However, this is rarely the case at the beginning of development processes. Mostly, prototypes or final products are tested on users (cf. also Sarodnick/Brau 2011). Even then, diversity is seldomly taken into account in the selection of test persons. More often, such tests take place online and in the confines of a tech-savvy community, which is easy accessible and has a high willingness to take part in testing these products. Little attention is paid to how representative these tests subjects are. Similarly, testing for research purposes is usually carried out using students, simply because they are available (Rommes 2014).

Due to a lack of comprehensive methodological knowledge, standardized usability tests in the form of questionnaires are often used to record user orientation. These are commonly not adapted to the specific research context and qualitative methods are rarely used to either interpret quantitative results or adapt quantitative instruments to the requirements of the research (Ohl/Schade 2015). Questionnaires are also the most widely used method for assessing usability of eHealth applications and while they provide a general measure of usability they do not help in identifying problems that may need to be addressed (Maramba et al. 2019).

Experiences with usability research also show that users often find it difficult to explain and express their wishes and needs. This "tacit knowledge", von Hippel calls the problem of "sticky information" (Von Hippel 2005, 67). The targeted involvement of users in the development process and the use of qualitative and creative methods can help to solve this problem and make "tacit knowledge" usable. Overall, there is a lot to be gained from user orientation in the development of technologies.

In this paper, we would like to describe two research projects for the purpose of this argument, which were both funded through the FFG FEMtech projects funding scheme[26]. In both, we have applied a user-centred approach in order to improve the usability and increase the benefits of specific and more diverse target groups.

- The aim of the **VR4Care project** was to develop a gender-sensitive VR application to increase motivation, activation and improve the overall quality of life for residents of long-term care facilities. As the project did not have a medical background or goal, it exclusively focused on VR as a form of leisure activity. Based on the results of focus groups conducted by our project partner the Medical University of Graz and a first round of evaluation with residents of a nursing home, a VR-App including some specialised content were developed. Its usability was then tested in a second evaluation round, together with relatives and caregivers who had helped the residents in using the VR-App. In this paper, we will now focus on the methodology used, the results of the two rounds of evaluation, as well as the literature review.

[26] The two projects were funded under the funding scheme FEMtech Projects by the Austrian Research Agency FFG with the following project numbers: VR4Care (FFG Project Nr. 873757) and FEMCharge (FFG Project Nr. 873011).

- In **FEMCharge**, a decision-analysis-tool for the future expansion and design of e-charging infrastructure was developed. The role of JOANNEUM RESEARCH Policies and thus the authors of this article was to bring in the user perspective. Using interviews and focus groups, we investigated the usage habits and needs of e-car drivers regarding charging stations and their usability.

After describing our methodological approach, we will then focus on the results of these two research projects and thereby investigate which benefits there are in considering gender when developing technologies and why it is not enough to just look at gender as an isolated variable. Finally, we reflect on our methodological findings and discuss how the dimensions of gender diversity and other aspects of diversity were taken into account in developing these technologies, what limitations were encountered and how these might be addressed in the future.

2 Case study 1: VR4Care - Gender-sensitive virtual technologies for the activation of seniors in long-term care

Methodology[27]

At the beginning of the project we conducted a literature review in order to identify how sex, gender and other diversity dimensions such as educational background or age might play a role when it comes to VR technology and the residents of nursing homes. Within the framework of the evaluation, there were two waves of data collection, which will be described separately:

The first wave of data collection was focused on the **residents' experience of VR technology** and took place from September to October 2020. The virtual reality (VR) scenarios[28] had already been identified in previous focus groups (Schüssler et al. 2021) and had subsequently been implemented in a first VR-prototype. These were then tested in a nursing home in Styria with 20 test subjects[29], half of which were men and women respectively. Similarly, half of the test participants were in wheelchairs. 11 of the test subjects had only completed compulsory education, while 9 subjects had

[27] More detailed information about the methodological design see: https://www.researchgate.net/publication/363567239_Gender-sensible_Virtuelle_Technologien_zur_Aktivierung_von_Seniorinnen_in_der_Langzeitpflege_D72_Ergebnisse_der_ersten_Evaluierungsrunde_FEMtech_Projekt_VR4CARE

[28] In order to get a clearer picture how these scenarios looked like, we will give two examples. In one scenario, the camera was put on the head of a person and this person walked through a forest, filming a walk in nature. In another scenario, the camera was put statically on the top of a vineyard, showing the view on other vineyards and hills (incl. a “Klapotetz”, a typically Styrian scarecrow).

[29] The test persons already had the opportunity to get familiar with the VR technology a few months earlier.

completed some form of higher education. Individuals with severe visual and hearing impairments, neurological disorders, moderate and severe dementia, reflex epilepsy, severe physical limitations, and severe medical conditions were excluded from the study. The aim of this specific user-test was to find out how the 360° photos and video clips would be received by residents and which content-related and technical improvements as well as other further development were necessary. Each subject selected five scenarios of interest for testing in advance using a catalogue of 20 360° photos and video clips. The first week of testing was conducted by researchers together with members of the staff of the nursing home. Afterwards, the technology remained in the nursing home and was made available to residents for four weeks for further use, which was aided and documented by the staff. Subjects were able to select 5 scenarios per week to view. The following data was collected:

- *SSQ questionnaires (n=40):* The Simulation Sickness Questionnaire measures whether the VR application has an effect on the physical well-being of test subjects. For this purpose, the questionnaire was filled out by researchers together with the test subjects, before and after the user-test in the first test week.
- *Observation sheets (n=20)*: These sheets were filled out by researchers during the user-tests. Statements and reactions of residents during the use of the VR-application were noted.
- *Interviews (n=20):* researchers conducted interviews with subjects about the perception of the technology and the scenarios, as well as possible complaints or wishes. Finally, one interview was conducted with the nursing staff, who aided and documented the VR application for another 4 weeks. The interviews were recorded on audio.
- *Documentation from the nursing home (n=78)*: During the 4 weeks in which the VR technology was used in the nursing home, a member of the nursing staff documented whether and why the technology was used or why it was rejected, which scenarios were in demand, etc. This documentation was forwarded to the researchers after the end of the test phase.

Following the test phase, the manually completed questionnaires, documentation, observation sheets and audio tracks were digitalised or put into writing and analysed using the MAXQDA software. In data analysis, an emphasis was placed on gender- and diversity-related aspects as well as their intersections in order to make the technology and its contents suitable for all possible users. The results were shared with our project partners in order to inform the further development of this technology. The second round of data collection focused on secondary end-users, such as nursing home staff and relatives and the usability of the VR-application. In June 2021, the prototype, developed in a previous work package was tested for usability at the same nursing home with five caregivers and five relatives. The aim of this evaluation was to find out how well the caregivers and relatives could handle the technical solution and to what extent it should be better adapted to their needs and if these two target groups find that the VR application has potential for use beyond the scope of the experiment. This evaluation was co-prepared by staff of the nursing home and carried out by researchers. The following data was collected:

- *Observation questionnaires (n=10):* These were filled out by researchers during the usability test. User's statements and general behaviour during the use of the application were recorded and even more details were added afterwards, since the screen itself was also recorded during the test.
- *Interviews (n=10):* Researchers conducted interviews with the test subjects about their perception concerning the usability of the VR application.
- *Questionnaires (n=10):* These questionnaires were filled out by test subjects together with researchers and recorded some personal characteristics such as gender, age, education and former occupation, as well as their familiarity with computers and frequency of computer usage.

After the test phase, questionnaires, observation sheets and audio tracks were digitalised and subsequently analysed, again using the MAXQDA software. Analogue to the first round, a conscious emphasis was placed on gender- and diversity-related aspects as well as their intersections in data analysis, in order to make the technology and its contents suitable for all possible users.

The pre-emptive literature review[30] had indicated that gender and other diversity dimensions could play a role in VR-usability. On the one hand, the effects of gender and age can be observed in the use of many modern technologies and a so-called digital divide can be identified for both. This means that although older people are increasingly using these technologies, their level of use and added-value tends to be lower and their perspective is more negative than that of younger people (Cai et al. 2017; Eurostat 2016; Niehaves/Plattfaut 2014; Peek et al. 2014; Teo 2010).

A similar digital divide is observed in gender-sensitive analysis: Social gender - especially certain ideas about masculinity - is an important key-moderator in relation to attitudes towards technology and related behaviour. In regard to intersectionality, older women tend to have a more negative and reserved attitude towards technology than men of the same age and use it less as well as with some time delay (Hergatt Huffman et al. 2013; Lafontaine/Sawchuk 2015; Ma et al. 2015; Nayak et al. 2010; Polizäus-Hoffmeister 2015; Reußer et al. 2015; Sáinz/López-Sáez 2010; Wang/Wang 2010). The fact that societal gender roles prove persistent even among those with dementia (Boyle 2017) underlines the relevance of intersectional approaches for our project.

In the context of VR technology, there already exist concrete indicators for the inclusion of gender. Firstly, the variety of body-types needs to be taken into account when

[30] As the literature research was conducted in the beginning of the project, it does not represent the current state of the art.

designing VR-equipment and other hardware: Ideally, the lens of VR goggles needs to be centred directly in line with the eye's cornea. However, interocular distance varies based on sex, age and ethnicity and therefore, VR-glasses should be individually adjustable (LaValle 2017; Gewickey et al. 2018). In terms of content adjustment, there is less need for change pertaining to the user's body and more need for adaptation pertaining to gender (Weiss et al. 2004). The leisure activities of older people are usually shaped by their different individual interests, which are in turn shaped by gender-specific socialisation, the formatted gender roles and expectations resulting from role affiliation among other things. Additionally, it can be assumed that even visually, interests diverge based on gender in regard to VR (Brockmann 1998; Dathe 2011; Hollneck 2009; Lothwesen 2014; Oesterreich/Schulze 2011).

Luckily, this circumstance has already been successfully countered with the development of virtual environments that are as gender-neutral as possible (Eisapour et al. 2018). We also learned, that when introducing people to VR, it is important to bear in mind that getting used to virtual space takes a different amount of time from person to person and that it can have a variety of side-effects (LaValle 2017).

One of the major issues is so-called cyber sickness, which, in contrast to travel- or sea-sickness is not necessarily stronger in women, but tends to occur more frequently with them (McGee 1998; Mourant et al. 2000; Zacharias 2014). Because of this, including approaches that can mitigate cyber sickness and observing it from a gender perspective is in order (Becker/Ngo 2016; Keshavarz/Hecht 2016). Furthermore, first signs have emerged that men tend to experience virtual reality as more immersive in physical interactions, while the use of virtual reality is most attractive to women when it comes to visual stimulation lacking physical interaction and movement (Felnhofer et al. 2012; Kothgassner et al. 2013).

The findings of the literature review were considered in compiling the sample and collecting and analysing the data. What follows are the results of the two rounds of data collection we conducted in VR4Care:

Following the goal of better tailoring VR-technology to the needs of the target groups such as nursing home residents, their caregivers and relatives, this evaluation was able to provide insights regarding VR-content as well as the physical design of the application. However, this article will mostly focus on those results related to gender and diversity.

For the user-tests with nursing home residents, 20 360-degree images and videos were selected, based on the focus group's desired content. Each test subject was able to choose 5 scenarios to try out during the user test. Particularly popular were vineyards, an alpine hut, gardening, a cow pasture and singing in the mountains. Regarding the subsequent individual rating of the content, we were able to identify only slight differences dependent on gender, most of which did not fit a specific pattern. Overall, nature-related scenarios users had a personal connection to, as well as scenarios, which included moderate amounts of movement and audio, were among the best received. In general, a combination of scenarios that offered a certain variety, but also put users in familiar environments and locations seemed to be important. However, with regard to subject's educational background, we found that people with higher levels of education were more willing to switch between the 20 scenarios on offer and view multiple scenarios over the course of the 4-week test period, when they had the option to use the VR-app once a week. People with lower levels of education tended to select the same scenarios to look at and switched less frequently. When asked about **additional desired content**, the difference between genders was small - women seemed to mention motives related to family somewhat more, while nature and foreign settings were somewhat more in demand among men. It was however noticeable that women, regardless of their educational background - showed a higher level of insecurity or even a negative attitude when asked about their wishes. Although, this reaction was not exclusive to female test subjects and also seemed to correlate with the level of care needed, it definitely seemed to be more pronounced with female users than male ones.

While it was always intended to obtain results on the perceived quality of the content, we also were able to obtain results on the **cinematic realization of VR scenarios**, which we did not foresee. Important factors here were the positioning of the camera (e.g. not too high or too close to objects, people, precipices), the speed of movement (not too fast). A majority of the comments on the level cinematic realization came from men.

Similarly, men commented more about the speed of the movement being too fast and complained about resulting dizziness, while women expressed slightly more anxiety about heights or steep slopes. The latter also seemed to be somewhat amplified with wheelchair users. Women with a low level of education also found it more difficult to state a critical perspective, while men expressed their opinion more freely, independent of their level of education.

Regarding the **physical effects of VR-technology**, men more often reported a slight strain on the eyes, while a feeling of pressure in the head was reported by only two of the female test subjects. Other problems, such as an increased difficulty focusing the eyes, mild fatigue, an upset stomach etc. were either relatively balanced between genders or did not occur at all.

During the second round of tests with relatives and caregivers on the **usability of the developed app**, the evaluation provided information on how to improve the user-interface, as well as recommendations for additional functionality. One example of features proposed, was being able to view what the user is seeing with the VR-goggles on a separate screen, so they have the possibility of talking about the content during the session. Contrary to the learnings from the literature review, female subjects coped better with using the VR-app in the usability test, than male test subjects. However, these differences might be attributable to age and experience with computers, as the female test subjects were younger on average and had more computer experience;

these two characteristics correlated in our study. Overall, the VR application was operable across all groups, with somewhat varying levels of support needed, which can be compensated through increased familiarization and a user-manual.

3 Case Study 2: FEMCharge – Gender- and diversity-appropriate positioning and equipment of e-mobility charging infrastructure

Methodology

As in the VR4Care project, a literature review was conducted for FEMCharge at the beginning of the project, to find out how gender and other diversity dimensions such as education or age might play a role in the use of e-mobility.
The data basis of the usability analysis were several online focus groups, as well as written responses to a set of interview questions and individual telephone interviews. In total, 16 people participated in the evaluation of the e-mobility charging infrastructure. Conducting focus groups was challenging due to coinciding with the COVID-19 pandemic. It was, thus especially difficult to reach a sufficient number of female e-car drivers for the sample. Therefore, individual telephone interviews with female customers of the Styrian energy provider Energie Graz were conducted. Through this, an equal number of female and male participants could finally be achieved. For our purposes, this deliberate diversification of the sample by way of including female and male, younger and older e-car owners as well as ones from economically different regions of Graz, seemed elementary to encompass a diverse range of perspectives, which might have remained partially hidden otherwise.
The resulting focus group data and interviews were recorded, put into writing and analysed qualitatively with the MAXQDA software.

Results

Our literature research[31] had shown that mobility has to always be considered embedded in existing societal structures, such as gender relations (VCÖ 2009). A variety of studies have similarly shown that women and men differ in their mobility behaviour (BMVIT 2016; Martens/Pauls 2001; Knoll 2013; 2016; CIVITAS; Muhr 2014; Amt der Steiermärkischen Landesregierung 2009; Glantschnigg/Hoser 2017; Peters 2013; Rasmussen 2009; Unbehaun et al. 2014a; 2014b; VCÖ 2009; 2015). This is mainly due to the distribution of labour that is part of traditional gender roles in relation to childcare, the care of relatives and working hours. Differences relating to gender can be found within the number of average journeys, the distance and duration of these journeys, the purpose of these journeys, the choice of transportation, the frequency of

[31] As the literature research was conducted in the beginning of the project, it does not represent the current state of the art.

accidents, and the general interest in e-mobility. On average, men also show a tendency for less complex mobility patterns with fewer, but longer journeys with less stops than those of women (Knoll 2013; Glantschnigg/Hoser 2017; Unbehaun et al. 2014b). While men and women without children primarily commute to work or to leisure activities, women with children do more service routes, e.g. driving the children. (Martens/Pauls 2001; Amt der Steiermärkischen Landesregierung 2009).
Similarly, women use a personal car less often and use public transport or walk instead (VCÖ 2018; Amt der Steiermärkischen Landesregierung 2009; Knoll 2013). Particularly young men are also more often involved in traffic accidents (Kuratorium für Verkehrssicherheit (KFV) 2017; Amt der Steiermärkischen Landesregierung 2009) and make up a higher percentage of traffic deaths (Das Land Steiermark 2019). According to a study from Germany, women are less likely to own an e-car (Cerbe/Machledt-Michael 2018). That there are gender differences in mobility behaviour seems obvious, however, these must be considered in the context of the living- and family-situation, phase of life, age, place of residence, socioeconomic position and cultural as well as ethnical background (Segert et al. 2017). Barriers to gender-responsive transport planning present as outdated concepts of transportation (Peters 2013), including male-dominated design of transportation-infrastructure (Rasmussen 2009; Pilz/Jauk 2005; Amt der Steiermärkischen Landesregierung 2009) and a lack of awareness when planning (Höller/Slamanig 2009; Unbehaun et al. 2014a, 2014b; Peters 2013).
As a consequence, marginalised groups have fewer opportunities for participation in urban planning (Martens/Pauls 2001), more anxiety and stress (Irschik 2013) and are more dependent on a car or another person with a car (Amt der Steiermärkischen Landesregierung 2009). The key to socially sustainable mobility is to ensure sufficient accessibility to relevant destinations, such as jobs, educational and supply facilities or leisure facilities for all groups of people (Lindner et al. 2016).
These findings from the literature review were considered in compiling the samples for the focus groups, designing data collection and analysis.
Over the course of FEMCharge, we gathered information on usage habits and factors for conveniently located charging stations, as well as wishes for the expansion of charging infrastructure and suggestions to improve the process of finding a charging station. The stations and charging app were also assessed regarding their user-friendliness.
The results were as follows:
In general, it can be said that the **research effort to find charging stations** and the higher effort for planning the charging activity are still a big challenge compared to the use of combustion vehicles. The use of the charging infrastructure is experienced as complex and non-transparent. In addition, information is often only available digitally, which can be an additional barrier, especially for older people. The high level of complexity also holds the potential to be a barrier for people who do not speak German such as tourists or people who are new to the country, since information was only

available in German. This user group might also lack contacts to other e-car owners to get help. The exchange of information among e-drivers was considered very helpful by the interviewees.
The **charging app** was slightly more popular among male respondents than among female ones. This could also be due to some women not using apps at all, while all male participants already use such apps and start the charging process more often with the app. The reason for this might be gender differences in socialisation, which make men tend to integrate technology more naturally into their everyday lives and have less reluctance than the majority of women.
Studies still show that women and men differ in terms of technology affinity and self-assessed technology competence (Reidl et al. 2020).
The effort involved in finding a free charging station, planning and carrying out the charging activity is also **difficult to integrate into the daily routine of working parents with small children** – here, it is still mostly mothers that shoulder this double burden. In the survey conducted by JR LIFE as part of FEMCharge (Seebauer et al. 2021), it became clear that women in particular, as well as people with lower incomes, are less willing or able to extend the length of stay for charging their car than men and people with higher incomes. It seems reasonable to assume, that this is due to a higher workload including unpaid work. Overall, the expansion of the charging infrastructure at locations central to everyday life as well as at home and a low-threshold provision of information (also offline, e.g. via telephone) would particularly benefit these groups.
The project was also key in identifying **concrete locations where charging stations are direly needed** in order to better integrate charging into a daily routine when there is no charging option at home. Fewer women than men reported being able to charge at work or at home. Here it would be interesting to see whether company charging stations tend to be found more commonly with employers in male-dominated industries and less in female-dominated fields like retail and elderly-care. This assumption is supported by the fact that in large cities more men than women have a parking space available at their place of work (BMK 2016). A focus on charging at the workplace also excludes the unemployed, pensioners, and those on parental leave or with other informal care responsibilities. At the same time, it would be interesting to investigate whether charging at home shows gender-specific differences in addition to differences specific to socioeconomic status. In the survey of JR LIFE within the framework of FEMCharge, it was also found that women are less likely than men to have a parking space at their place of residence or work. People with higher incomes are more likely to have a parking space at their place of work. Similarly, women and lower-income individuals see little or no opportunity to retrofit charging infrastructure at their place of residence. This underlines the assumption that there are gender and class-specific differences and this is a public infrastructure issue.
Additionally, the **costs of charging** was a central topic during the interviews and focus groups. Still, the high financial costs of e-mobility compared to combustion vehicles

represent an essential barrier, especially for people from lower income households. As women have a higher risk of poverty than men do and there is an evident gender pay and wealth gap (Statistik Austria 2020, 2021; Schneebaum et al. 2018), electric mobility is more difficult to afford for women than for men. This barrier mainly concerns the high purchase costs for private e-mobility. This is confirmed by a study from Germany, which shows that private e-drivers are predominantly male and come from educated milieus with a higher income, and are on average 51 years of age (Lenz et al. 2015).

Currently, charging costs are measured on a time basis rather than on a kW basis, which disadvantages certain groups with older, smaller and less expensive cars with lower charging capacities. People who therefore cannot use fast charging stations to their full capacity would like to be able to use them (also in terms of price) as "normal" charging stations. Otherwise, people with cars without the option of fast charging are financially disadvantaged and often have to switch to other “slower” charging stations. The group which did not use fast charging stations consisted exclusively of women. This is not to conclude that these are irrelevant for female e-drivers. However, further research should investigate whether women tend to drive cars with a lower charging capacity and driving range and thus benefit less from the implementation of fast charging stations.

In a study conducted in Denmark, Finland, Iceland, Norway and Sweden, some respondents still associated the size of a car with masculinity, even though this seems to be changing. Furthermore, “women report stronger preferences for environmentally friendly vehicles or those with better safety measures. Women similarly give less importance to acceleration, power, or sound, whereas men emphasize range, supposed sex appeal, and acceleration” (Sovacool et al. 2019). In a study for German market research with 1000 subjects, women showed fewer reservations towards the low range of e-cars (F: 28%, M: 46%) and thus seem to be open-minded towards smaller models with a lower range (puls Marktforschung 2017). Fittingly, female respondents in our study were more satisfied with the space available at the charging stations than men, which also suggests that they often have smaller cars. If this assumption were to be proven true, this means that women would be more disadvantaged by the charging measure based on time as opposed to kW.

4 Discussion and Reflection

The two projects show that we were able to produce gender- and diversity-specific results that are relevant for the further development of both technologies. Conclusively, we would also like to reflect on how this intersectional approach has worked in both projects and what its limitations are.

In VR4Care, the literature analysis showed gender and sex related differences in intraocular distance and other physical and psychological features in VR. Moreover,

gender together with age, education and occupational experience influence the interest to use VR technology (see grey coloured arrows in figure 1). As has been described, we actively tried to consider these dimensions in choosing our samples. This turned out to be quite challenging because of the relatively small number of nursing home residents who were physically, mentally and cognitively able to participate at all. The first round of evaluation confirmed some differences regarding gender, age and educational background, as described above. Moreover, we have found that there are differences in the feeling of safety during VR use between wheelchair users and non-wheelchair users. Additionally, the evaluation revealed that nursing home residents would not be able to use this technology independently.
The second evaluation round with relatives and caregivers showed that experience with computers is a key factor in supporting residents in using VR. This experience is of course a result of education, occupational experience and age (see figure 1).

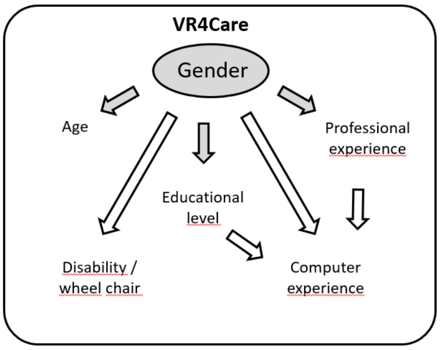

Figure 7: VR4Care - relevant diversity dimensions

In the literature review for FEMCharge, we found that gender specific mobility patterns are an issue, which is often influenced by informal care responsibilities and therefore life phases, but also regions of residence (see grey coloured arrows in figure 2). For this reason, we compiled our samples according to these criteria. In the interviews and focus groups, the usage of the charging app turned out to be challenging, especially for older e-car drivers with less computer experience. Moreover, we could identify discrimination of e-car drivers with cheaper and smaller cars, which are far more likely to be women. Additionally, we found that men were more likely to mention the possibility of charging at work, leading to the suggestion that male-dominated industries may be more likely to provide charging stations.

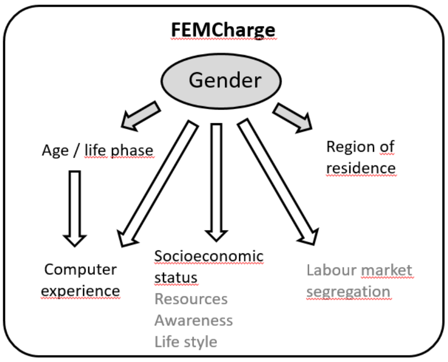

Figure 8: FEMCharge – relevant diversity dimensions

Overall, both projects have allowed us to add new perspectives and knowledge of intersectional contexts in both fields of research - even if these concepts of intersectional contexts remain simplified.
In both projects, the intersectional approaches spanned from the literature review, to the sampling, to incorporating findings from the literature in data collection instruments and data analysis as well as finally developing recommendations for more inclusive technology development. We actively tried to recognize people's multiple, interdependent and overlapping needs and axes of social identity (Crenshaw 2017), such as gender, socioeconomic status, age, disability, technological competence etc.
However, due to the projects operating with small samples and on a qualitative basis we could only show which other diversity dimensions might be of relevance but could not investigate their interdependence. Therefore, a quantitative analysis with representative results would be required, which was not possible within the scope of these projects due to resource constraints. Even apart from limited resources, the question arises how to conduct a representative quantitative intersectional analysis and deal with the multidimensionality of diversity.
Our experience in VR4Care and FEMCharge also showed that it can be very challenging to compile diverse samples. In both projects, we were only able to select from a very limited pool of potential participants. Sometimes we had to be glad to get any participants at all. In a next project (FairCom) about using and designing online communication inclusively, where we are currently trying to include a gender diverse group of subjects, recruiting people with a diverse gender identity (e.g. non-binary) turns out to be even more difficult. For example, databases are still mostly created in a gender-binary way, which makes it difficult to address people specifically and correctly.
Especially when using participatory methods in technology development, there is another question of how to avoid involving a majority of extroverts. Introverts or those with sometimes self-perceived lower social-skills or educational distance very rarely come forward to participate in research projects.

In conducting the interviews in VR4Care, we also learned that elderly women with low education levels did not criticize VR technology at all. This leads to the assumption that women with lower education find it harder to criticise and to articulate their needs - perhaps due to gender-specific socialization. It is difficult to deal with this inherited reticence in research projects and not ignore the special needs of this group. Presumably, this would require data collection over a longer period of time by trusted individuals such as caregivers.

It can therefore be assumed that there are more barriers to participation in user-centred studies for (multiply) marginalised groups. For example, a working person with children and distant relatives will have even more limited time resources than a working person with children but sufficient (informal) childcare. Privileged people are more likely to assume that their opinion is relevant and important and should therefore be expressed - this may not be the case for marginalised groups. This is another common way research bias persists. In a current project, we are trying to address this problem by selecting people from observations and asking for support from multipliers. Overall, we face the challenge of developing our recruitment strategies as well as communication and methods to ensure that everyone feels welcome. A financial allowance can also be a way to value the invested time and sharing of negative experiences and knowledge of discrimination.

Overall, we see that an intersectional approach demands engagement, creativity and flexibility and must always be adapted to the specific context. Perhaps we also need the courage to leave gaps in data and set certain priorities, since diversity usually cannot be taken into consideration in its full variety without overwhelming us. Nevertheless, we try to use the results of these projects with their limitations for the benefit of all, to contribute to the development of more inclusive and user-friendly technology.

References

Amt der Steiermärkischen Landesregierung (2009): 5. Teilbericht. Frauen und Mobilität. In Amt der Steiermärkischen Landesregierung (Hg.): Erster Steirischer Frauenbericht.

Backhaus, C. (2009): Usability-Engineering in der Medizintechnik - Grundlagen, Methoden, Beispiele, Springer, Berlin

Becker, Jackie; Ngo, Thu (2016): Mitigating Visually-Induced Motion Sickness in Virtual Reality. Ed. v. Stanford University.

BMBWF, BMVIT, BMDW (2019): Österreichischer Forschungs- und Technologiebericht 2019. Lagebericht gem. § 8 (1) über die aus Bundesmitteln geförderte Forschung, Technologie und Innovation in Österreich. Available under: https://www.bmbwf.gv.at/dam/jcr:6c2909b9-d953-4575-8aed-50e705999f8a/Forschungs-_und_Technologiebericht_2019_dt_bf.pdf .

BMK (Hrsg.) – Österreich unterwegs (2016). Ergebnisbericht zur österreichweiten Mobilitätserhebung „Österreich unterwegs 2013/2014“. https://www.bmk.gv.at/dam/jcr:fbe20298-a4cf-46d9-bbee-01ad771a7fda/oeu_2013-2014_Ergebnisbericht.pdf

BMVIT (2016): Österreich unterwegs 2013/2014. Ergebnisbericht zur österreichweiten Mobilitätserhebung „Österreich unterwegs 2013/2014“. Wien.

Boyle Geraldine (2017): Revealing gendered identity and agency in dementia. In Health Soc Care Community 25:1787–1793. https://doi.org/10.1111/hsc.12452

Brockmann, Hilke (1998): Die Lebensorganisation älterer Menschen. Eine Trendanalyse. Wiesbaden: Springer Fachmedien Wiesbaden.

Cai, Zhihui; Fan, Xitao; Du, Jianxia (2017): Gender and attitudes toward technology use. A meta-analysis. In Computers & Education 105, S. 1–13.

Criado Perez, Caroline (2019): Invisible women. Exposing data bias in a world designed for men.

Cerbe, Thomas; Machledt-Michael, Sonja (2018): Die Elektromobilität ist WEIBLICH. Ein Transferprojekt zur Begeisterung von Frauen für E-Mobilität (E-Pkw und Pedelecs) gefördert vom Amt für regionale Landesentwicklung Leine-Weser des Landes Niedersachsen. Schlussbericht. Ostfalia Hochschule für angewandte Wissenschaften.

CIVITAS: Gender equality and mobility: mind the gap! CIVITAS (CIVITAS WIKI Policy Analyses series, 2).

Crenshaw, Kimberlé W., "On Intersectionality: Essential Writings" (2017). *Faculty Books*. 255. https://scholarship.law.columbia.edu/books/255

Curcio, Karina; Santana, Rodolfo; Reinehr, Sheila; Malucelli, Andreia (2019): Usability in agile software development: A tertiary study. In Computer Standards & Interfaces 64, 61-77.

Das Land Steiermark (2019): Steiermark Straßenverkehr 2018. Kfz-Bestand, Neuzulassungen und Unfallgeschehen. In Steirische Statistiken (4).

Dathe, Dietmar (2011): Monitor Engagement. Wie und wofür engagieren sich ältere Menschen? Ausgabe Nr. 4. Unter Mitarbeit von Franziska Paul und Clemens J. Poldrack. Hg. v. Bundesministerium für Familie, Senioren, Frauen und Jugend. Berlin.

Eisapour, Mahzar; Cao, Shi; Domenicucci, Laura; Boger, Jennifer (2018): Participatory Design of a Virtual Reality Exercise for People with Mild Cognitive Impairment. In CHI 2018, April 21–26, 2018, Montréal, QC, Canada.

EIGE (2021): Gender Equality in Academia and Research (GEAR) Tool. Rationale for gender equality change in research and higher education institutions. Available under: https://eige.europa.eu/gender-mainstreaming/toolkits/gear/rationale-gender-equality-change-research-and-innovation

European Commission (2014): Vademecum on Gender Equality in Horizon 2020, Brussels.

European Commission, Directorate-General for Research and Innovation (2021): Horizon Europe. Strategic plan 2021-2024, available under https://data.europa.eu/doi/10.2777/083753

Eurostat (2016): Internet access and use statistics - households and individuals. Available under http://ec.europa.eu/eurostat/statistics-explained/index.php/Internet_access_and_use_statistics_-_households_and_individuals.

Eurostat (2021): File:V1 Distribution of persons employed as ICT specialists by sex, education attainment level and age, 2012 and 2021 (%). Available under: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:V1_Distribution_of_persons_employed_as_ICT_specialists_by_sex,_education_attainment_level_and_age,_2012_and_2021_(%25).png

Felnhofer, Anna; Kothgassner, Oswald D.; Beutl, Leon; Hlavacs, Helmut; Kryspin-Exner, Ilse (2012): Is Virtual Reality for Men only? Exploring Gender Differences in the Sense of Presence. Conference Paper.

Franklin, Rebecca C. (2021): Black workers in Silicon Valley: macro and micro boundaries. In Ethnic and Racial Studies 45(1).

Gewickey et al. (2018): Warner Bros. Entertainment Inc. Immersive Virtual Reality Production and Playback for Storytelling Content. United States patent US 10, 109,320B2.

Glantschnigg, Christian; Hoser, Bernhard (2017): Mobilitätsverhalten von Frauen und Männern in unterschiedlichen Lebenslagen. Auswertungen der österreichweiten Mobilitätserhebung „Österreich unterwegs 2013/2014“ nach Haushaltstyp, Geschlecht und räumlicher Lage. SORA Ogris & Hofinger GmbH. Wien.

Hergatt Huffman, Ann; Whetten, Jason; Huffman, William H. (2013): Using technology in higher education. The influence of gender roles on technology self-efficacy. In Computers in Human Behavior 29 (4), S. 1779–1786.

Höller, Christian; Slamanig, Ruth (2009): Planende beziehen sich auf die eigene Alltagserfahrung. Interview mit Brigitte Jilka. In VCÖ Magazin (1), S. 5.

Hollneck, Ulrike (2009): Freizeitverhalten im höheren Lebensalter. Einflussfaktoren und Hemmnisse. Rostock.

Irschik, Elisabeth (Hg.) (2013): Handbuch Gender Mainstreaming in der Stadtplanung und Stadtentwicklung. STEP 2025 Stadtentwicklungsplan. Wien: Stadtentwicklung Wien MA. 18 - Stadtentwicklung und Stadtplanung (Werkstattberichte / Stadtentwicklung, 130).

Keshavarz, Behrang; Hecht, Heiko (2016): Visually induced motion sickness and presence in videogames. The role of sound. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting 56 (1), S. 1763–1767.

Knoll, Bente (2013): Auswertung der Tiroler Mobilitätserhebung nach gender- und gesellschaftsrelevanten Fragestellungen. Büro für nachhaltige Kompetenz. Wien.

Kothgassner, Oswald D.; Felnhofer, Anna; Beutl, Leon; Heinzle, Anna-K.; Gomm, Jasmine; Kastenhofer, Elisabeth et al. (2013): Geschlechterunterschiede in der Nutzung von kollaborativen virtuellen Umwelten bei gesunden Älteren. Der Einfluss von Sozialer Präsenz, Benutzerfreundlichkeit und Technikängstlichkeit.

Kuratorium für Verkehrssicherheit (KFV) (2017): Verkehrsunfallstatistik. Straßenverkehrstote nach Alter und Geschlecht (2017). Kuratorium für Verkehrssicherheit (KFV). Available under https://unfallstatistik.kfv.at/index.php/verkehr-mobilitat/getotete-im-verkehr-nach-alter-und-geschlecht.

Lafontaine, Constance; Sawchuk, Kim (2015): Accessing InterACTion: Ageing with Technologies and the Place of Access. In Jia Zhou and Gavriel Salvendy (Eds.): Human Aspects of IT for the Aged Population. Design for Aging. First International Conference, ITAP 2015, HCI International: Springer International, S. 210–220.

LaValle, Steven (2017): Virtual Reality. Ed. v. Cambridge University Press.

Lenz, B., Frenzel, I., Jarass, J., & Trommler, S. (2015). Erstnutzer von Elektrofahrzeugen in Deutschland. Berlin Eigenverlag. https://elib.dlr.de/96491/1/Ergebnisbericht_E-Nutzer_2015.pdf

Lindner, Christine; Horn, Daniel; Louen, Conny (2016): Identifikation geschlechterspezifischer Mobilitätsbarrieren anhand einer drittvariablengestützten Mobilitätsverhaltensanalyse. In Manfred Schrenk, Vasily V. Popovich, Peter Zeile, Pietro Elisei und Clemens Beyer (Hg.): REAL CORP 2016. Smart Me Up! How to become and how to stay a Smart City, and does this improve quality of life? : proceedings of 21st international conference on Urban

Planning, Regional Development and Information Society = Beiträge zur 21. internationalen Konferenz zu Stadtplanung, Regionalentwicklung und Informationsgesellschaft; Tagungsband: CORP - Competence Center of Urban and Regional Planning, S. 349–356.

Lothwesen, Kai (2014): Dimensionen von Motivation und Involvement in nichtprofessionellen Chören und Orchestern. Eine explorative Untersuchung. In b:em (1).

Ma, Qi; Chen, Ke; Chan, Alan Hoi Shou; Teh, Pei-Lee (2015): Acceptance of ICTs by Older Adults: A Review of Recent Studies. In Jia Zhou and Gavriel Salvendy (Eds.): Human Aspects of IT for the Aged Population. Design for Aging. First International Conference, ITAP 2015, HCI International: Springer International, S. 239–249.

Maramba, Inocencio; Chatterjee, Arunangsu; Newman, Craig (2019): Methods of usability testing in the development of eHealth applications: A scoping review. In International Journal of Medical Informatics 126, 95-104.

Martens, Sabine; Pauls, Kerstin (Hg.) (2001): Gendergerechte Verkehrsplanung. Slogan, Mode, Utopie oder praxistaugliche Planungshilfe?; Ergebnisse des Workshop XIV im Themenbereich Verkehr und Raumstruktur [25.04.2001 in Stuttgart-Hohenheim. Workshop im Themenbereich Verkehr und Raumstruktur; Akademie für Technikfolgenabschätzung in Baden-Württemberg. Stuttgart: Akad. für Technikfolgenabschätzung in Baden-Württemberg (Arbeitsbericht / Akademie für Technikfolgenabschätzung in Baden-Württemberg, 206).

McGee, Michael K. (1998): Assessing Negative Side Effects in Virtual Environments. Masterarbeit. Virginia Polytechnic Institute and State University.

Mourant; Ronald R.; Thattacherry; Thara R. (2000): Simulator Sickness in a Virtual Environments Driving Simulator. In Proceedings of the IEA 2000/HFES 2000 Congress, 534-537.

Muhr, Barbara (2014): Neue Formen der Mobilität. In if: Steirisches Frauenmagazin (2), S. 2–3.

Nayak, Laxman U. S.; Priest, Lee; White, Allan P. (2010): An application of the technology acceptance model to the level of Internet usage by older adults. In Univ Access Inf Soc 9 (4), S. 367–374.

Niehaves, Björn; Plattfaut, Ralf (2014): Internet adoption by the elderly: employing IS technology acceptance theories for understanding the age-related digital divide. In European Journal of Information Systems 23, S. 708–726.

Oesterreich, Detlef; Schulze, Eva (2011): Frauen und Männer im Alter. Fakten und Empfehlungen zur Gleichstellung. edition sigma, Berlin.

Ohl, Christoph & Schade, Gabriele, (2015). Klassifikationsschema für Usability-Evaluationsmethoden. In Diefenbach, Sarah, Henze, Niels & Pielot, Martin (Hrsg.), Mensch und Computer 2015 – Proceedings. Berlin De Gruyter Oldenbourg. (S. 33-42).

Peek, Sebastiaan T. M.; Wouters, Eveline J. M.; van Hoof, Joost; Luijkx, Katrien G.; Boeije, Hennie R.; Vrijhoef, Hubertus J. M. (2014): Factors influencing acceptance of technology for aging in place. A systematic review. In International journal of medical informatics 83 (4), S. 235–248.

Peters, Deike (2013): Gender and Sustainable Urban Mobility. Thematic study prepared for Global Report on Human Settlements 2013. University of Southern California.

Pilz, Cosima; Jauk, Daniela (2005): Gendersensitive Governance im Bereich Verkehr und Mobilität. Frauen machen schön mobil. Kurzfassung. Unter Mitarbeit von Katja Hartl und Werner Reichmann.

Polizäus-Hoffmeister, Helga (2015): Verjüngung des Alters durch Technik. Das subjektive Altersbild im Kontext des technischen Wandels. In Marcel Plechaty und Frieder R. Lang (Hg.): Ältere Menschen in der Mediengesellschaft. Regionale Konferenzen für Bayern. November 2013 bis Juli 2014, S. 82–103.

puls Marktforschung. (21. 11 2017). puls Publikationen. Elektromobilität braucht motivierte Händler, plus Studie zu den Erfolgsfaktoren des Verkauf von Elektroautos. https://www.puls-marktforschung.de/medien/pressemitteilungen/elektromobilitaet-braucht-motivierte-haendler.html

Rasmussen, Ulla (2009): Verkehr in Europa. Lass die Frauen ankommen! In VCÖ Magazin (1), S. 3.

Reidl, Sybille; Streicher, Jürgen; Hock, Marlene; Hausner, Beatrix; Waibel, Gina; Gürtl, Franziska (2020): Digitale Ungleichheit. Wie sie entsteht, was sie bewirkt … und was dagegen hilft. Available under: https://www.femtech.at/content/digitale-ungleichheit-wie-sie-entsteht-was-sie-bewirkt-und-was-dagegen-hilft

Reußer, Josephine; Schuberth, Katrin; Seiler, Gerhard (2015): Tablet PCs für Seniorinnen und Senioren: Erfahrungsbericht und Evaluationsergebnisse 2012 – 2014. In Marcel Plechaty und Frieder R. Lang (Hg.): Ältere Menschen in der Mediengesellschaft. Regionale Konferenzen für Bayern. November 2013 bis Juli 2014, S. 104-131.

Rommes, E. (2014): Feminist Interventions in the Design Process. In Ernst, Waltraud; Horwath, Ilona (Eds.): Gender in Science and Technology. Interdisciplinary Approaches. Transcript Verlag, Bielefeld. 41-55

Sáinz, Milagros; López-Sáez, Mercedes (2010): Gender differences in computer attitudes and the choice of technology-related occupations in a sample of secondary students in Spain. In Computers & Education 54 (2), S. 578–587.

Sarodnick, F.; Brau, H. (2011): Methoden der Usability Evaluation. Wissenschaftliche Grundlagen und praktische Anwendung. 2., überarbeitete Auflage. Bern: Verlag Hans Huber.

Schiebinger, Londa (2008): Introduction: Gettting more Women into Science and Engineering - Knowledge Issues. In: Schiebinger, Londa (Ed.): Gendered Innovations in Science and Engineering, Stanford University Press, California, S 1-21.

Schneebaum, A.; Rehm, M.; Mader, K.; Hollan, K. (2018). The Gender Wealth Gap Across European Countries. Review of Income and Wealth, 64 (2). pp. 295-331. ISSN 1475-4991

Schnögl, Sonja (2009): Kleine Schritte mit großer Wirkung. In VCÖ Magazin (1).

Schraudner, M.; Seewald, B.; Trübswetter, A.; Luge, M. K.; Kimpel, K.; Mizera-Ben Hamed, K; Heidingsfelder, M.L.; Rehberg, M.; Martinides, M. (2013): Discover Markets. Vorgehensmodell für eine methodengestützte, nutzerzentrierte Technologieentwicklung. Fraunhofer.

Schüssler, Sandra; Häussl, Alfred; Paletta, Lucas; Binder, Thomas; Fürli, Hermine; Koch, Beatrix; Reidl, Sybille; Beranek, Sarah; Hartmann, Robert; Sighart, Martin (2021); Schneeberger, Michael; Andreu, Jean-Philippe: Interests of nursing homes residents with dementia for virtual reality-based leisure activities: A cross-sectional pilot study. In Alzheimer's & dementia: the journal of the Alzheimer's Association 17(S11).

Seebauer, Sebastian; Gruber, Christian; Reidl, Sybille; Seyfried, Linda; Bergmann, Ulrich; Beran, Manuela; Weissenbacher, Elena (2021): Endbericht FEMCharge.

Segert, Astrid; Brunmayr, Eliza; Ibrahimoglu, Figen; Lüle, Gül; Sarikaya, Nurgül; Wolf, Hilde (2017): Frauen in Fahrt. Research Report. Endbericht. Institut für Höhere Studien (IHS). Wien.

Sovacool, Benjamin K.; Kester, Johannes; Noel, Lance; Zarazua de Rubens, Gerardo (2019): Are electric vehicles masculinized? Gender, identity, and environmental values in Nordic transport practices and vehicle-to-grid (V2G) preferences. In Transportation Research Part D: Transport and Environment 72, 187-202.

Statistik Austria (2020). Armuts- oder Ausgrenzungsgefährdung. https://www.statistik.at/web_de/statistiken/menschen_und_gesellschaft/soziales/gender-statistik/armutsgefaehrdung/index.html

Teo, Timothy (2010): Gender differences in the intention to use technology. A measurement invariance analysis. In British Journal of Educational Technology 41 (6), E120-E123.

Unbehaun, Wiebke; Favry, Eva; Gerike, Regine; Hader, Thomas; Knoll, Bente; Schwaninger, Teresa; Uhlmann, Tina (2014a): Unterwegs zwischen Erwerbs- und Familienarbeit. Eine Analyse in den niederösterreichischen Regionen Triestingtal und Schneebergland. Wien (Verkehr und Infrastruktur).

Unbehaun, Wiebke; Uhlmann, Tina; Hössinger, Reinhard; Leisch, Friedrich; Gerike, Regine (2014b): Women and Men With Care Responsibilities in the Austrian Alps: Activity and Mobility Patterns of a Diverse Group. In Mountain Research and Development 34 (3), 276–290. DOI: 10.1659/MRD-JOURNAL-D-13-00095.1.

VCÖ (2009): Gender Gap im Verkehrs- und Mobilitätsbereich. Hintergrundbericht zum VCÖ-Projekt „Gender und Verkehr“. Wien.

VCÖ (2015): Gesellschaftliche Entwicklungen verändern die Mobilität.

VCÖ (2018): Mobilität als Soziale Frage.

Venkatesh, Viswanath; Morris, Michael G.; Davis, Gordon B.; Davis, Fred D. (2003): User Acceptance of Information Technology. Toward a Unified View. In MIS Quarterly 27 (3), 425–478.

Von Hippel, E. (2005): Democratizing Innovation: The evolving phenomenon of user Innovation. Cambridge (Massachusetts), London: MIT Press.

Wang, Hsiu-Yuan; Wang, Shwu-Huey (2010): User Acceptance of Mobile Internet Based on the Unified Theory of Acceptance and Use of Technology. Investigating the Determinants and Gender Differences. In Social Behavior and Personality 38 (3), 415–426.

Weiss, Patrice L.; Rand, Debbie; Katz, Noomi; Kizony, Rachel (2004): Video capture virtual reality as a flexible and effective rehabilitation tool. Journal of Neuroeng. and rehabilitation 1 (1), 1–12.

Zacharias, Konrad (2014): Motion Sickness in Virtual Reality Umgebungen. Bachelorarbeit. Goethe Universität, Frankfurt a.M. Fachbereich Informatik.

Participatory Online Idea Labs: Empowering Social Workers in Dealing with Digitalization

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Abstract. The Covid-19 pandemic accelerated digitalization processes in the field of social work. While some areas, such as IT infrastructure, improved, others remained the same or even worsened, such as the lack of co-determination in selecting, implementing, and evaluating digital tools. Against this background, we discuss participation opportunities for social workers in their organizations. We ask how they can actively participate in developing digitalization strategies or accompany other processes in this regard. The focus is on our method of participatory online idea labs, which enables the development of recommendations for action from practice for practice. We present the method's goals and structure in detail before we evaluate its advantages, such as empowering employees, and challenges, such as reaching out to techno-skeptic people. At the end of this paper, we discuss individual recommendations for action, which refer to the possibilities for employees to participate in the digitalization of their working environment and which are also presented in a toolbox.

1 Introduction

Against the backdrop of societal changes that are gradually leading to a "digital society" (Lindgren, 2017), the field of social work[32] is undergoing fundamental transformations. Digitalization processes are changing the working conditions for and tools of social workers as much as organizational cultures (Zierer, 2018). With regard to clients, digital technologies and the emergence of new social spaces are shaping their (living) environment (Becka, Evans and Hilbert, 2017). Therefore, social workers must adapt to these new environments and refer to them in their work. Besides, digital technologies open up new possibilities to support clients, e.g., through online counseling (Kutscher, 2016). On a communicational level, social work institutions and professionals are increasingly presenting themselves via social media and on websites relevant to the

[32] We use 'social work' as a convergence term of social pedagogy and social services. Social work takes place in a variety of action fields. In these, social workers support and accompany the shaping and management of their clients' everyday lives. Their responsibilities involve educational, supportive, preventive, and intervening tasks, and they work in counseling centers, residential communities, or youth centers (Klinger, Mayr and Sackl-Sharif, 2019).

field (Klinger, Mayr and Sackl-Sharif, 2019). Case administration and documentation are progressively digitized and used for billing services or evaluating social workers (Ley and Seelmeyer, 2014). As a consequence, social work employees need new digital literacies that enable them to use digital tools, create online content or discuss the risks of social media with people addressed (Austrian Federal Ministry for Digital and Economic Affairs, 2018). At the same time, social work institutions face the challenge of developing digitalization strategies for their institution. And they have the task of selecting and implementing new digital tools which fit their work environment (Klinger, Mayr and Sackl-Sharif, 2022).

Before the Covid-19 pandemic, the field of social work in Austria faced many challenges related to digitalization processes compared to other sectors such as education, industry, or media (Klinger, Rauter and Sackl-Sharif, 2022). In our last project digi@work[33], social workers complained about poor technical equipment. They had to work with inadequate software that did not correspond to the logic of their working practices. In this regard, managers mentioned a lack of necessary capital to buy up-to-date tools or software (Klinger, Mayr, Rauter and Lerch, 2020). Furthermore, social workers often expressed skepticism towards digitalization. For example, they feared dehumanization or total surveillance through digital tools. Some had a dystopian future vision and feared the social workers' replacement by robots or the decline in relationship work (Klinger, Mayr and Sackl-Sharif, 2022). And most important for this paper: They had hardly any opportunities to select or evaluate the new digital tools. Therefore, social workers often felt unheard and left alone with technical innovations (ibid).

In our follow-up project digi@socialwork[34], we focused on participation possibilities for social workers to support their wish to shape digitization processes. Based on empirical surveys and participatory research in Austria, we developed recommendations for action with social workers. Proceeding in such an inclusive way, our recommendations shall find a higher acceptance and implementation rate among practitioners and shall facilitate and improve their digital literacies, the introduction of new digital tools and the development of digitalization strategies. The results of the project digi@socialwork relate to the aggravated work situation during the Covid-19 pandemic. Therefore, it is

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[33] The digi@work project was carried out between 2018 and 2020 at the University of Graz, FH JOANNEUM – University of Applied Sciences, Know-Center Graz, and x-samples. For more information, see https://digital-at-work.uni-graz.at. We applied a mixed-methods approach and compared for-profit organizations (FPO) with non-profit organizations (NPO). In a first step, we conducted a quantitative telephone survey with executives of 178 different organizations (92 FPO, 87 NPO). In a second step, we conducted 12 case studies (4 FPO, 8 NPO) and interviewed 14 executives in form of problem-centered interviews and 58 employees in 15 group discussions.

[34] The digi@socialwork project was funded by the "Digitalisierungsfonds 4.0" of Arbeiterkammer Steiermark. It was carried out between 2020 and 2022 at the Institute of Educational Sciences (University of Graz). For more information, see https://digital-at-socialwork.uni-graz.at.

also possible to draw comparisons with the pre-pandemic period and see how the pandemic affected and changed the field of social work.

In this paper, we discuss the participatory research design of the project digi@socialwork in detail. After outlining our research design, we focus on the method of participatory online idea labs, explaining the empirical basis, the process, and the evaluation of these labs. In this context, we discuss the advantages and challenges of developing recommendations for action directly from the researched field. In the end, we present selected results of our toolbox as well as our compendium of relevant recommendations for action, and highlight the most useful insights.

2 Research Design: An Overview

In the project digi@socialwork, we focused on the perspective of social work employees in Austria. The central goals of this project were

- to survey how social workers experience digital transformation processes,
- to develop recommendations for action from practice for practice, and
- to discuss participation possibilities for social workers to strategically, transparently, and actively shape digital transformation processes.

In this way, digitalization should not only serve the economy but also support employees and improve their everyday working lives.

2.1 Participatory Mixed-Methods Design

To achieve these goals and to integrate the views of social workers in the best possible way, we chose a participatory research approach. We understand participatory research as a cognitive process of researchers and social workers as co-researchers guided by a continuous exchange of information (Kemmis and McTaggart, 2005). Against this background, participatory research means entering into a conversation with the research partners about their work lives and making explicit what in practice has long been known already implicitly (Bergold and Thomas, 2010). This approach can succeed if a research environment is created on an equal footing, in which power structures are eliminated as far as possible and in which practical and theoretical knowledge enter into a productive exchange (e.g., Moser, 2008).

In the digi@socialwork project, the participation of social workers was based on a three-stage mixed-methods research design (Kuckartz, 2014). We combined and conducted the following methods sequentially:

1. *Quantitative survey*: an online survey with employees of social work institutions in Austria,
2. *Qualitative survey*: group discussions with employees of social work institutions in Austria,

3. *Participatory online idea labs*: participatory online workshops with social work employees.

In this context, we understood participation in two ways: In the online survey and the group discussions, we included social workers in a more 'classical' sense and asked pre-formulated items or questions. These surveys were relevant to identifying current challenges regarding digital transformation processes in social work. In the idea labs, we involved the participants already in the topic preparation. In this last part, the degree of participation was much higher as the relevance of the topics came largely from social workers.

2.2 Online Survey

The Austria-wide online survey served as a collection of basic information on the digital tools' usage of social work employees.[35] The data collection was carried out between March and May 2021 with SoSci and comprised closed and open questions on the employees' everyday working lives. The questionnaire included nine topic blocks:

- Opinion on digitalization in general
- Self-assessment of private and professional skills in dealing with digital technologies
- Usage behavior of digital technologies at the workplace (end devices and application software)
- Rules and guidelines for the use of digital technologies
- Satisfaction with the equipment in the company
- Need for participation and support
- Effects of digitalization on the compatibility of professional and private life
- Data security
- Socio-demographic questions

Based on a maximum variation sampling strategy (Patton, 2002), we tried to include as different social organizations as possible in our survey. The sample comprises seven selected organizations, which vary in size (number of employees), geographical distribution, and action fields to cover the Austrian social work landscape. We included the following action fields: work with children, youth and families; work with people with disabilities; work with people with a migration background; care; and psychosocial work.

1,273 people completed the questionnaire up to the last question. We excluded 27 questionnaires because there were more than 10% unanswered questions. In the end, our sample included 1,246 persons. The following socio-demographic variables were relevant for our analysis:

[35] Waltraud Gspuring largely planned, conducted, and analyzed our online survey. She was supported in particular by Patrick Hart but also by the rest of the project team.

- *Gender*: Three-quarters of the respondents were women* and one-quarter were men*.[36] A total of nine people indicated their gender as diverse.
- *Age*: About 60% of the respondents were between 36 to 55 years old. A fifth was 26 to 35 years old, 10% were 56 years and older, and about 9% were 19 to 25 years old.
- *Working hours*: About 40% of the respondents were employed full-time, and about 60% were employed part-time. Of the part-time employees, most worked 30 hours per week (n=201), followed by 25 hours per week (n=107) and 20 hours per week (n=97).
- *Care work*: About 20% of the participants had one child, 16% had two children, and 4% had three children up to 18 years. Furthermore, 12% of the participants provided private care for relatives other than their children. On average, these participants cared for their relatives 21 hours per week.

Furthermore, also the participants' affinity for technology was an important topic for our analysis and they had to rate four items related to this on a five-point rating scale. Our sample included many IT literate participants. 53% usually do (tend to) not need support when using new digital technologies, 60% are (tend to be) among the first in the team to use new digital technologies and 60% are (tend to be) asked for advice by others when it comes to new digital technologies. The final item rated the relation regarding the use and the novelty of new digital technologies. It turned out that 80% of the participants (tend to) use the latest digital technologies in their work.

We analyzed the closed questions with descriptive statistical evaluations and selected items with inferential statistics. We clustered the two open questions with the qualitative content analysis (Mayring, 2015) and MAXQDA20.

2.3 Group Discussions

From May to August 2021, we conducted nine (online) group discussions (Mangold, 1973) with 25 social workers to learn more about their practical experiences and perspectives. We discussed five topics: attitudes towards and experiences with digitalization; significance of digitalization for one's work context; balancing professional life and private life; digitization during the Covid-19 pandemic; and organizational framework. At the end of the discussion, participants filled in a short questionnaire with socio-demographic information.

We selected the participants based on the maximum variation sampling strategy (Patton, 2015), whereby we also considered particularities of the field, such as the higher proportion of women*. We included seven different organizations which vary in size (number of employees), geographical distribution, and action fields. Our sample comprised five action fields respectively target groups (work with people with disabilities; work with people in a migration context; work with children, young people,

[36] The gender asterisk * after a word serves as a reference to the constructional character of gender.

and families; area of psychosocial activities). 16 women* and 9 men* between 30 and 53 years participated in the group discussions.
In evaluating the group discussions, we were guided by the evaluation strategies of Schmidt (2013) that constitutes a compilation of different evaluation techniques based on existing theories (Kuckartz, 2010). Since Schmidt (2013) mainly referred to interviews, we adapted this procedure for group discussions (for more information, see Klinger, Mayr and Sackl-Sharif, 2022). We carried out our analysis with computer support using MAXQDA20.

2.4 Participatory Online Idea Labs and Toolbox

From January to February 2022, we conducted ten participatory idea labs to develop recommendations for action together with social workers. Our findings from the online survey and the group discussions were the basis for these idea labs. Therefore, we used the labs not only to discuss recommendations but also to validate our previous findings. Since this method is the main focus of this contribution, information on the structure and procedure of the idea labs will be provided in the following sections.
In the last step of the project, we transformed the results of the idea labs into a toolbox. The toolbox includes recommendations for actions for the most relevant topics. At the end of this contribution, we give an overview of the toolbox' structure and content and discuss the most relevant results to enable better participation of social workers in their organizations.

3 Idea Labs: Empirical Basis

In the preparation phase of our idea labs, we linked the main findings from the online survey and the group discussions. In particular, we were interested in surprising results that emerged by comparing the situation before and during the Covid-19 pandemic and existing challenges in dealing with digital tools.
One surprising finding from the group discussions was that attitudes toward digital tools improved strongly during the Covid-19 pandemic. The widespread dystopias were hardly present anymore, in contrast to the situation before the pandemic (Klinger, Mayr and Sackl-Sharif, 2022; Klinger, Rauter and Sackl-Sharif, 2022). It seems that former challenges have turned into potentials. The Covid-19 pandemic was a driver of digitalization in the field of social work on different levels. For example, many organizations improved their IT infrastructure, social workers developed and expanded their digital literacies, and they began to perceive digital tools increasingly as necessary. In our idea labs, we discussed how organizations and social workers could maintain these positive attitudes and improvements in the future.
But we also identified different longer existing and new challenges related to digital tools or digital transformation processes. The most relevant topic for this contribution is the lack of opportunities for employees to participate in decision-making. Our online

survey showed that only about 20% of respondents indicated on a five-point rating scale that they are (very) satisfied with the transparency of decisions and the opportunities for co-determination in their organization. There seems to be a deficit in organizational support in considering employees' opinions in selecting digital technologies. About two-thirds of the respondents felt unheard and excluded from decision-making. Our group discussions indicated that social workers have special insider knowledge and a desire to be more involved in decision-making. In their opinion, social workers' involvement in developing, selecting, implementing, and evaluating new tools is indispensable. In our idea labs, we discussed possible ways to implement these wishes in practice.

During the Covid-19 pandemic, many social workers had the chance or the obligation to work from home. We identified some challenges also in this context. Across our surveys, it became apparent that data protection was sometimes perceived as problematic in the home office, as the family or flat mates could listen in on meetings, and the protection of clients was challenging. Furthermore, there were uncertainties regarding data protection when working with personal devices. Here, social workers expressed their desire to develop guidelines for using personal devices in the workplace, as these were still lacking at many organizations during our surveys. Therefore, data protection was also a relevant topic for our toolbox.

In addition to data protection problems, working in a home office also led to more work-life balance problems. Employees who cared for relatives in their private lives also rated their work-life balance significantly worse than employees who did not care for relatives. However, the number of children did not show a significant difference. In addition, the respondents often lacked contact with their colleagues in the home office. Digital platforms such as MS Teams could not fully replace analog meetings in their point of view. Besides, the possibility of being permanently available via digital tools was a big problem in balancing professional and private life for many social workers. They experienced this challenge even more intensely in action fields with on-call duty. Almost 92% of our online survey respondents answer e-mails or telephone with colleagues at least sometimes in their free time. Almost a third say they are always available for colleagues or superiors. Interestingly, social workers located challenges concerning the work-life balance to an individual level. Being able to say no, being mindful of oneself, or simply switching off the mobile phone were mentioned as solution strategies for compatibility/availability problems. In our idea labs, we focused on what organizations could do for their employees in this context. For example, we discussed rules and guidelines for accessibility in the free time or possible improvements for the organizational culture in this regard.

4 Idea Labs: The Process

4.1 Preparation

In the first step, we identified challenges in dealing with digital tools and surprising findings in five areas: creating participatory work environments; organizational framework such as organizational culture and the existence or absence of a digitalization strategy; balancing professional life and private life; working conditions such as work hours, salary, equipment, or technical support; and using digital tools (digital literacies).

We organized two idea labs for every topic, each lasting two hours. Zoom, Webex, and Big Blue Button served as communication channels during the labs, and the participants discussed and worked together on Miro, a visual collaborative online platform. It was relevant for us to design our Miro boards very open so the participants could set their priorities themselves.[37]

4.2 Recruitment

We recruited participants through our contacts in the field and participants in our online survey and group discussions. All participants received a reward of 150 euros. In advance, we informed all participants about the goals and topics of our five different idea labs, from which they were able to choose their two favorite topics. In this way, we tried to select the participants by their interests to guarantee their active participation. In the next step, we carried out the time-consuming task of coordinating viable time slots for all participants according to their topic choice. In the last recruitment phase, we sent all participants the link and password for the respective communication platform, their topic, the moderator's name, and their time slot.

In contrast to our previous surveys, we could not carry out the sampling process in such a structured way because the idea labs took place during a hard lockdown which led to many work routines being interrupted. Therefore, we had difficulties finding two to three social workers who had time during the same period and were interested in similar topics.

All in all, 23 people from the field of social work participated in our ten idea labs. They were between 21 and 55 years old, about two-thirds were women*, and one-third were men*. They also came from different action fields and organizations similar to our previous surveys. Most participants were IT literate and open for new digital technologies. Due to the challenges in the recruitment process described above (hard lockdown, time slots shared by several participants), it was not possible to consciously invite participants who were skeptical about technology. Nonetheless, skeptical opinions were also represented in at least a few idea labs. Approximately one quarter

[37] Eva Goldgruber designed and developed our Miro boards and helped us with her expertise in e-learning and online research.

of the participants also discussed the dangers of social media or criticized digitalization in general in the first phase of the idea labs.

4.3 Welcome and Explanation

The labs started on the respective communication platform. At the beginning of the labs, the moderator (Susanne, Sabine, or Andrea) introduced the process, showing the Miro board with a shared screen and the most relevant functions. She explained the different colored post-its on the board and instructed each participant to choose and use one specific color for the whole Miro board. In this way, we could collect the ideas of each participant separately in the following analysis.

4.4 Introduction Round

Afterward, an introduction round served to get to know each other and become acquainted with Miro (see Fig. 1). The participants received the task of writing their names and action fields on prepared post-its and completing the sentence “When I think of digitalization, I think of...”. In addition, the participants had to indicate on a 10-point rating scale how relevant digital tools and digitization processes are to their work practice. This allowed us to estimate their general opinions on digitalization in the workplace.

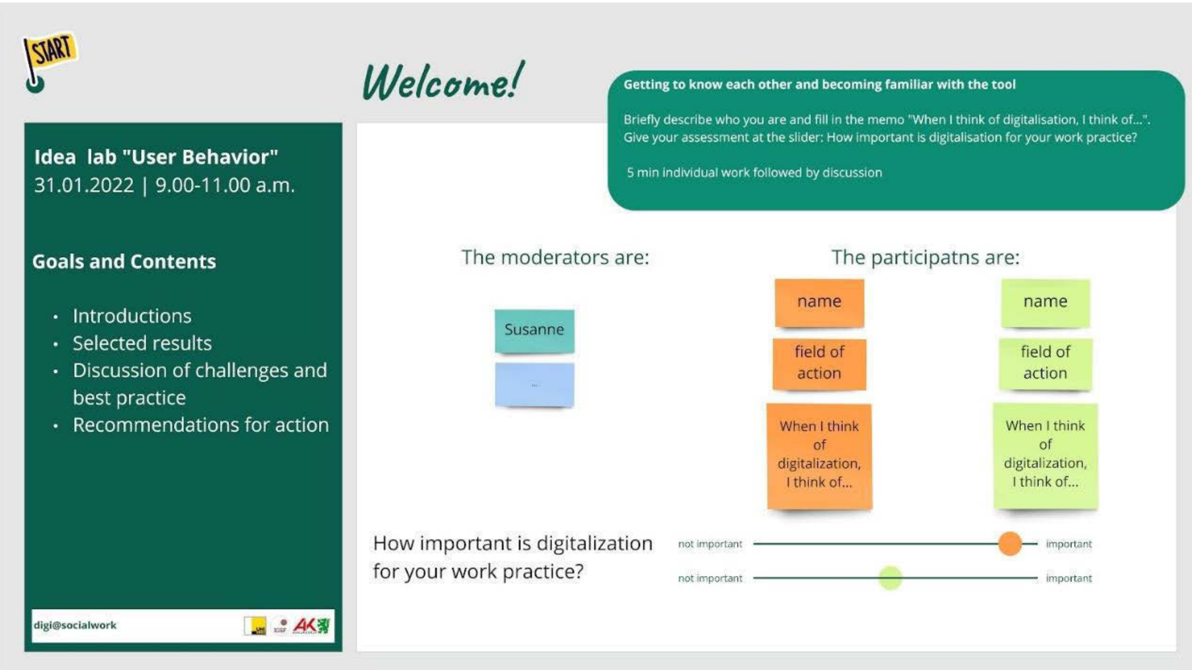

Fig. 1: Introduction Round.

4.5 Empirical Results

In the next phase, the moderator presented the most important results from the online survey and the group discussions that fit the topic of the respective idea lab on a new Miro frame. By this means, the participants could jump back to the results at any time during the lab. This phase lasted about five to ten minutes and the participants had the opportunity to ask comprehension questions in case of ambiguities.

4.6 Brainstorming

Afterward, the participants were asked to discuss the results, collecting best practice examples from their working practice, or identifying further challenges in a two-step process (see Fig. 2). First, the participants brainstormed alone for five to ten minutes and wrote their thoughts and ideas on the prepared post-its. Second, the social workers presented and discussed their notes while the moderator clustered shared insights and problems.

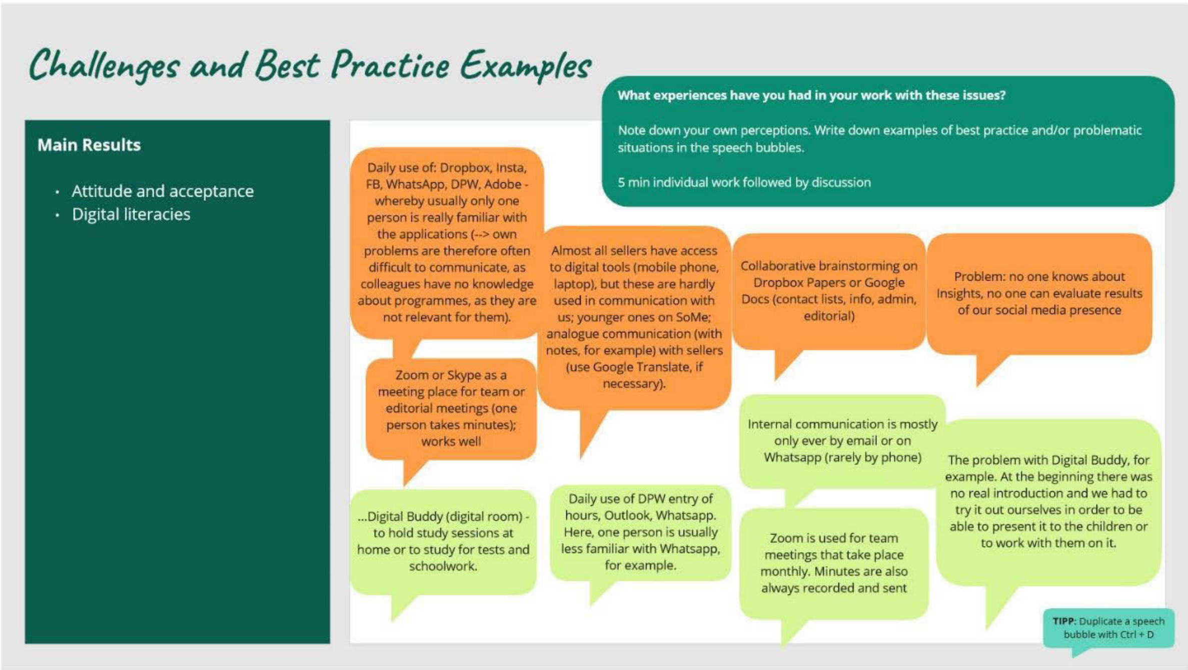

Fig. 2: Brainstorming.

4.7 Selecting Relevant Problems

For the subsequent phase, we provided a separate voting frame to select problem areas for which recommendations for action were to be developed (see Fig. 3). Here, the moderator first noted challenges from the empirical results. The participants were also able to list further challenges from the previous phases in the lab. Afterward, the participants received five points each to assign them to the challenges on the board, whereby a maximum of three points per challenge was allowed. The social workers discussed the topic that received the most points first. Depending on the progress of the labs, they also discussed a second topic if there was enough time. Through this approach, we ensured that the respondents only discussed those topics that were relevant to them.

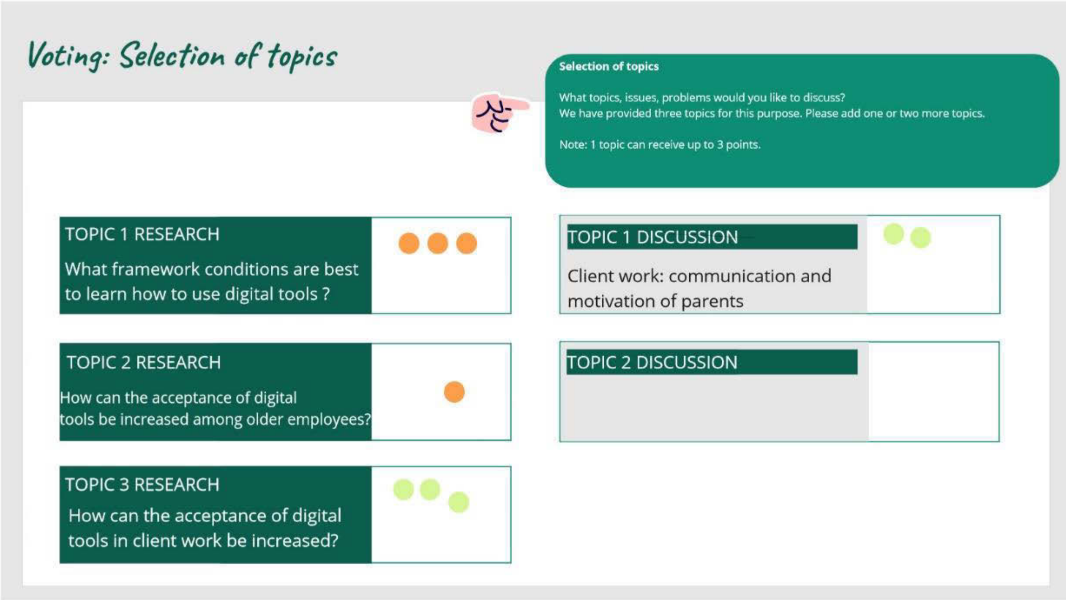

Fig 3. Voting frame.

4.8 Recommendations for Action

In the next phase, we invited the participants to develop recommendations for action based on their professional experiences (see Fig. 4). Once again, we first asked the participants to brainstorm independently and, then, to discuss their ideas in the group. During these complex discussions, the moderators noted relevant findings and recommendations. Due to the collaborative work with Miro, all contents were always visible to all participants. Moreover, it was possible to cluster the outcomes together.

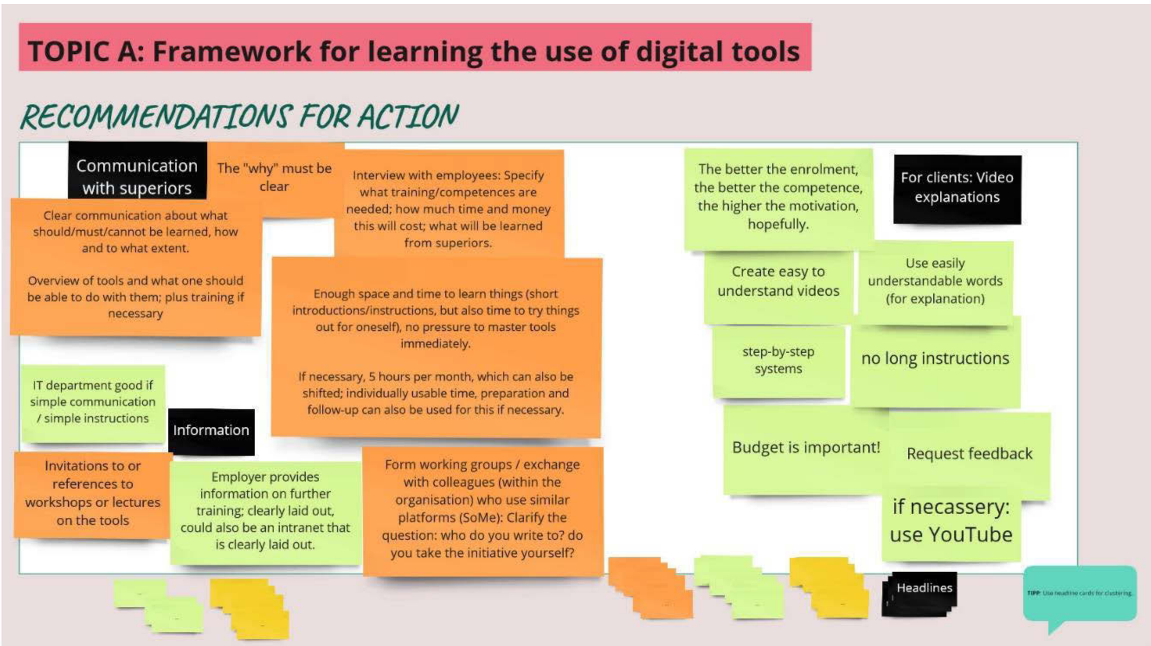

Fig 4. Developing recommendations for action.

4.9 Reflexion and Goodbye

On completion of all tasks after about two hours, each idea lab ended with a short feedback round, in which we asked the participants what they took away from the idea labs, how they liked it, and which topics were most important for them. We also informed them about the next steps of our project and invited them to our closing event.

5 Idea Labs: An Evaluation

From a methodological point of view, the structure and process of the idea labs worked well in practice. The participants accepted the Miro board well and had hardly any problems with its use. In about half of the idea labs, mainly the participants documented the ideas and best practice examples. In the other half, the moderators had to support and note essential findings, as the participants focused on the discussion and sometimes forgot about documenting. Similar to group discussions in general, we had to use flexible strategies in the role of moderators depending on the group dynamics.
The group size of two to three participants turned out to be suitable. In this way, the participants could set the relevance of the labs' contents. With larger groups, consensus-building might not have succeeded so quickly. Due to our step-by-step approach, the participants especially developed recommendations for action for those topics where they had practical experience in. This means that our results came directly from the social workers' practice, which suggests that the toolbox subsequently developed from is more likely to be accepted by practitioners.
The participants perceived the exchange in the idea labs very positively. They felt inspired and empowered. The reflection on their practice led some participants to view digitalization in a more positive or relevant way in the final round than at the lab's beginning. They were also more likely to feel they could change or contribute to their organization by participating in digital transformation processes. The participants felt motivated by the cross-organizational setting of the idea labs as they had the chance to reflect on their practice and learn more about digital transformation processes and digitization strategies in other organizations. Cross-organizational idea labs can also help to reduce reservation and even resistance against digitalization and increase social workers' empowerment.
The only methodological challenge, for which we have yet to find a solution, is the following: We had the impression that especially IT literate social workers participated in the idea labs as well as in our other surveys. With our design, we could hardly reach people with skeptical attitudes towards digitalization. Perhaps the hurdle of using digital tools was too big here, even though our recommendations for action are intended precisely for this group.

6 Toolbox: Recommendations for Action from Practice for Practice

6.1 Creating the Toolbox

The consolidation of all findings from our surveys and idea labs was also carried out with a Miro board, as this tool enables transparent, collaborative, and flexible work. It is also easy to save the intermediate status of the different brainstorming and evaluation phases. The development of the recommendations for our toolbox took place in numerous discussions among the authors, including one active and two former social workers to maintain the practical relevance. We clustered our recommendations into seven main topics:

- *Strategies*: We discuss the advantages of having a digitalization strategy and describe relevant topics as well as possible ways of implementation.
- *Tools*: We deal with the equipment of social workers (hardware, software) and the selection and implementation processes of new digital tools.
- *Digital literacies*: We describe opportunities for sustainable acquisition of skills perceived as essential for the digital age.
- *People addressed/clients*: We explain how it is possible to get or stay in touch with clients via digital tools and work together on creative digital solutions.
- *Flexible work environment*: We show that work independent of time schedule and location requires very flexible rules to, for example, counteract compatibility problems.
- *Data security*: We draw attention to possible data protection problems and show solution strategies.
- *Cross-organizational cooperation*: We discuss the advantages of cross-organizational cooperation.

For each topic, we created an easy-to-understand headline and a motto (e.g., 'Digital change does not come out of the socket but starts in people's heads!'). In the section 'Good to Know', the toolbox explains key terms and summarizes relevant results. Furthermore, it contains a list of recommendations for action and best practice examples. The toolbox is available as a poster, Pdf-file and a short video on our website.[38]

6.2 Recommendations for Actively Shaping Digital Transformation

We identified possibilities for shaping digital transformation by social workers in connection with many topics. In this contribution, we focus on one relevant example: the *digitalization strategy*. Our analyses show that the existence of a digitalization strategy enables better participation of social workers but also enhances other

[38] https://digital-at-socialwork.uni-graz.at/toolbox

processes. If an organization has a clear digitalization strategy and communicates it transparently to its employees,

- this has a positive effect on the perception of the use of digital tools in everyday work,
- it tends to be better equipment or software that fits the work steps and systems in which tools are tried out and consciously selected before their use,
- digitization becomes something self-evident,
- there are more formal support systems (IT, training),
- social workers have more opportunities to participate in selecting, implementing and evaluating tools.

If no digitization strategy is in place, there is often the feeling that organizations implement too many ideas and use too many different software solutions simultaneously. Social workers experience new digital tools' introduction more likely as abrupt and little prepared. They describe more challenges in dealing with digital tools, such as missing digital literacies or too less time for training, and often feel not integrated into decision-making. Therefore, we recommend a clear digitalization strategy development with representatives from all organizational levels to guarantee the support of as many organization members as possible. This strategy should also be transparently communicated to everyone and written in a simple language.

7 Conclusions and Discussion

The Covid-19 pandemic acted as an accelerator for digitalization processes in the field of social work. Challenges that were experienced as a burden before the pandemic, partly developed into potentials. To give an example: Whereas before the pandemic, social workers associated time tracking with digital tools with surveillance and control (Klinger, Rauter, Sackl-Sharif 2022; Klinger, Mayr, Sackl-Sharif 2022), they see it now as a way of facilitating their work by keeping track of clients and tasks. Furthermore, social workers have a more open attitude towards digitalization since the beginning of the pandemic and report being better at using digital tools. Nevertheless, there are a number of new as well as existing challenges, for example, in the area of increasingly flexible working, work-life balance, the selection, introduction, and evaluation of new tools, or digital communication with colleagues and clients.

Against this background, we developed recommendations for action from practice for practice together with social workers in participatory online idea labs. The focus was on what organizations can do to support their employees to accept the digitalization process and improve their digital literacies. In particular, it was relevant to find out how employees can participate in developing visions and strategies and what co-decision making could look like in selecting and introducing new digital tools. The open structure of our participatory online idea labs worked well in practice as social workers had the opportunity to set their own priorities. This approach made it possible to develop recommendations for action that are relevant to the participants' working practice.

After the end of the project, we distributed our posters and sent our link to the toolbox to all participating organizations and individuals as well as to other stakeholders in the field of social work in Austria. The feedback we have received up to the time of writing this report (August 2022) has been consistently positive. The recommendations for action were written in a language that was easy to understand and could be put into practice. Some also reported that they had hung up the poster in their office so that they could better remember the recommendations in their daily work.

Our participatory research approach, particularly the online idea labs, is also well suited for other research projects with a focus on participatory work with the project's target groups. However, since online tools can reach especially IT literate people, we recommend a broader research approach. In addition to online surveys, offline surveys/events could help reach out to people with less digital literacies and less open attitudes toward digitalization.

Acknowledgments

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References

Austrian Federal Ministry for Digital and Economic Affairs (2018) 'Digital competence framework for Austria: DigiCom 2.2 AT' [online]. Available at: https://www.bmdw.gv.at/en/Topics/Digitalisation/For-citizens/Digital-literacy.html (Accessed 6 June 2022)

Becka, D., Evans, M. and Hilbert, J. (2017) *Digitalisierung in der sozialen Dienstleistungsarbeit. Stand, Perspektiven, Herausforderungen, Gestaltungsansätze*. Düsseldorf: Forschungsinstitut für gesellschaftliche Weiterentwicklung e.V. Available at: http://www.fgw-nrw.de/fileadmin/user_upload/FGW-Studie-I40-05-Hilbert-komplett-web.pdf (Accessed 6 June 2022)

Bergold, J. and Thomas, S. (2010) ‘Partizipative Forschung’, G. Mey and K. Mruck (eds) *Handbuch Qualitative Forschung in der Psychologie*. Wiesbaden: VS Verlag für Sozialwissenschaften, pp. 333–334.

Kemmis, S. and McTaggart, R. (2005) ‘Participatory action research. Communicative action and the public sphere’, K. N. Denzin and Y. S. Lincoln (eds) *Handbook of qualitative research*. Thousand Oaks, CA: Sage, pp. 559–603.

Klinger, S., Mayr, A., Rauter, R. and Lerch, A. (2020) ‘Digital und/oder analog? Zusammenarbeit am Arbeitsplatz im Gesundheits- und Sozialwesen aus der Perspektive von Führungskräften’, *soziales_kapital*, 24, pp. 377–391.

Klinger, S., Mayr, A. and Sackl-Sharif, S. (2022) ‘Digitalisierung der Handlungspraxis in der Sozialen Arbeit. Kontrastierungen nach Angebotsstrukturen und Zielgruppen [69 Absätze]’, *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, 23(2), Art. 14 [online]. Available at: https://doi.org/10.17169/fqs-22.2.3851. (Accessed 6 June 2022)

Klinger, S., Mayr, A. and Sackl-Sharif, S. (2019) ‘Digitalisierung in den Handlungsfeldern der Sozialen Arbeit’, J. Muckenhuber, M. Griesbacher, J. Hödl and K. Scaria-Braunstein (eds) *Intensivierung der Arbeit. Perspektiven auf Arbeitszeit und technologischen Wandel*. Wien and Hamburg: New Academic Press, pp. 113–122.

Klinger, S., Rauter, R. and Sackl-Sharif, S. (2022) ‘Using digital media and technologies in the workplace. A spotlight on individual and organisational determinants in Styrian for-profit and non-profit organisations’, S. Hummel et al (eds) *Shaping tomorrow today. SDGs from multiple perspectives*. Wiesbaden: Springer VS, pp. 359–389.

Kuckartz, U. (2010) *Einführung in die computergestützte Analyse qualitativer Daten.* 3.rd edn. Wiesbaden: VS Verlag für Sozialwissenschaften.

Kuckartz, U. (2014) *Mixed Methods. Methodologie, Forschungsdesigns und Analyseverfahren*. Wiesbaden: Springer VS.

Kutscher, N. (2016) ‘Mediatisierung der Kinder- und Jugendhilfe. Herausforderungen der digitalen Gesellschaft für professionelle Handlungskontexte’, Arbeitsgemeinschaft für Kinder- und Jugendhilfe (ed.), *Gesellschaftlicher Wandel. Neue Herausforderungen für die Kinder- und Jugendhilfe?!* Berlin: Arbeitsgemeinschaft für Kinder- und Jugendhilfe, pp. 39–58.

Ley, T. and Seelmeyer, U. (2014) ‘Dokumentation zwischen Legitimation, Steuerung und professioneller Selbstvergewisserung’, *Sozial Extra*, 1, pp. 51–55.

Lindgren, S. (2017) *Digital media and society*. London: Sage.

Mangold, W. (1973) ‚Gruppendiskussion‘, R. König (ed.) *Handbuch der empirischen Sozialforschung*. Stuttgart: Enke, pp. 228–259.

Mayring, P. (2015) *Qualitative Inhaltsanalyse*. 12.th edn. Weinheim and Basel: Beltz.

Moser, H. (2008): ‘Aktionsforschung unter dem Dach der Praxisforschung. Methodologische Herausforderungen und Lösungsansätze’, H. von Unger and M.T. Wright (eds), *“An der Schnittstelle von Wissenschaft und Praxis”. Dokumentation einer Tagung zu partizipativer Forschung in Public Health*. Berlin: Wissenschaftszentrum Berlin für Sozialforschung, pp. 58–66.

Patton, M. Q. (2002) *Qualitative research and evaluation methods*. 3.rd edn. London: Sage.

Schmidt, C. (2013) ‘Analyse von Leitfadeninterviews’, in: U. Flick, E. von Kardorff and I. Steinke (eds), *Qualitative Forschung. Ein Handbuch*. Berlin: Rowohlt, pp.447–456.

Zierer, B. (2018): ‘Analog und digital! Den digitalen Wandel aktiv mitgestalten’, *SiO Fachzeitschrift für Soziale Arbeit in Österreich*, 3(18), pp. 11–16.

Towards transparent municipal open data: risks, illusions and opportunities in a growing field

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Abstract. In the last years, many municipalities started to embrace the potential of open data, who envision open data as a mean to substantially enhance transparency and accountability towards citizens, restore trust in public services and increase citizens' participation and engagement. However, the flip side of open data rarely surfaces when municipalities report on their open data successes. This paper attends to the dark side of open data by examining open data extracted using the FixMyStreet API, to report incidents of urban disorder, nuisance and minor crimes in the Brussels' streets, by visualizing the aggregated data through a dashboard. Our approach illustrates that open data has a malleable character and breaks with several of the eight 'Sebastopol principles' of open data: (1) Only a fragment of reported data is available; (2) The data is not primary, since information is sometimes added by third parties; (3) Interventions are not always added in a timely fashion, with little to no information on the handling of the incident. This results in inaccurate data; (4) Reasonable privacy restrictions are lacking. The open data pose a risk to citizens' and municipal employees' privacy, and is non-compliant with GDPR regulations. Given these limitations, we argue that there are risks of misinterpreting or misusing this fragmented and inaccurate data, leading to misinformed citizens and policymakers. These risks underpin the need for a transparent data policy that allows open data initiatives to deliver on their promises and enables citizens to meaningfully engage with the urban environment and its complexities.

1 Introduction

In this research, we focus on the quality of municipal open data and its unintended consequences. While there are several definitions for open data available, most descriptions have in common that data is considered 'open' when it can be collected and shared with others, to use as they wish, without restrictions on copyright or usage (a.o. Ayre and Craner, 2017, Máchová et al., 2018). Open data (OD) is often used exchangeable with big data (BD), but it is important to distinguish both concepts. BD is defined by its size: it is data that no longer be handled by traditional tools or databases. OD, on the other hand, is characterized by its availability: it is available to anyone and can be used and re-used without restrictions (Janssen et al., 2015). OD can be 'big', but this is not necessarily the case. OD fosters new opportunities for both public servants and citizens but introduces some important caveats at the same time. We elaborate the risks, illusions and the opportunities of this field that is evolving continuously.

Under the impetus of technological advancements cities have digitized most information in recent years. Fostering a drive to elevate data to better information, city administrations globally started publishing parts of this data as OD. Cities historically always had a central role in the collection and generation of data on their territory and inhabitants. Data on housing, income levels, labor and road infrastructure are just a few examples. In a recent past, however, cities and municipalities simply put out summarizing reports and citizens had to request specific information (Ashlock, 2013). This turn to OD can be considered an extension of regular communication channels and traditional reports (Lauriault and Francoli, 2017). It has the potential to offer more and better information faster and on a larger scale.

The trend towards open government data (OGD), or OD commissioned by government-controlled entities, is visible globally but the stimuli for opening city databases to the general public is diverse. Some motivations can be traced to the ideology of freedom of information and democratic values (Janssen, 2011). Rationale is that revealing this data could increase transparency, citizen engagement and empowerment, and even co-creation of public services and policy. At the same time, openness of data is thought to decrease corruption and bring accountability. Information is considered a prerequisite for a properly functioning democracy and OGD can play a significant role in this process (Harrison and Sayago, 2014). It allows citizens to grasp and accept decisions that affect them directly (Meijer et al., 2012). Another motivation is rather economic in nature. Publishing this data and creating opportunities to link datasets might improve government efficiency and therefore reduce organizational costs. Furthermore, OGD can create significant additional economic value due to the development of innovative tools that build on this data (a.o. Janssen, 2011, Styrin et al., 2017).

The 'techno-fetishist' perspective (Jefferson, 2020), that focuses on the upside of OGD, has been criticized by several scholars. Habib et al. (2022) argue, for example, that OGD differs significantly from government reports. These traditional reports usually contain extensive analysis of context-bound data, collected through well-defined methods, and were converted to human-readable format. OGD, however, is 'raw data'. It is often void of contextual information and should therefore be handled as a 'black box'. Furthermore, government institutions tend to operate in a closed culture that might prevent the disclosure of data (Huijboom and Broek, 2011). Managers can fear that publishing data might illustrate a lack of operational effectiveness. In fact, there often seems to be a lack of understanding of the value of OGD as an advantage that can increase public services' effectiveness (Ruijer et al., 2020). Other scholars warn that OGD is rarely checked and lacks options to assess the quality of the data, which can lead to decisions based on data of poor quality or even data that is non-compliant with legislation (a.o. Zuiderwijk and Janssen, 2014).

As argued by Janssen et al. (2012), OD itself has little intrinsic value; the actual value is created by its use. A prerequisite for optimal value creation, however, is having quality data to start from (Lessig, 2017). In 2007, thirty prominent open data advocates gathered in Sebastopol, California to formulate the fundamental principles leading to qualitative OGD (Malamud et al., 2007). Today, these eight 'Sebastopol principles' are still considered the corner stone for efficient OGD and are the foundation of most guidelines for publishing OGD, allowing to reap the full potential of OGD and, at the same time, providing the necessary conditions for data usability (Attard et al., 2015). The principles state that open government data should be:

(1) *Complete*: All public data is made available. Public data is not subject to privacy, security or privilege limitations.
(2) *Primary*: Data is collected at the source, with the highest possible level of granularity, not in aggregate or modified forms.
(3) *Timely*: Data is available as quickly as possible to preserve the value of the data.
(4) *Accessible*: Data is available to the widest range of users for the widest range of purposes.
(5) *Machine processible*: The data should be reasonably structured to allow automated procession.
(6) *Non-discriminatory*: Data is available to anyone, with no requirement of registration.
(7) *Non-proprietary*: Data should be available in a format over which no entity has exclusive control.
(8) *License-free*: Data is not subject to any copyright, patent, trademark, or trade secret regulation. Reasonable privacy, security and privilege restrictions may be allowed.

Despite the benefits of OGD, and the concrete guidelines to achieve qualitative data that can be reused in order to create added value for internal and external users, we hypothesize that the importance of qualitative data is still highly undervalued and associated risks are neglected. Therefore, we focus in this paper on the quality assessment of OGD based on the Sebastopol principles. If issues are found, the second objective is to reflect on the (un)intended consequences of identified issues, and how these might be solved. FixMyStreet Brussels (FMS) is used as a case study (CIBG, 2013). FMS is a popular state-citizen app that allows citizens to report incidents of urban disorder, nuisance and minor crimes in the streets to the municipality. Incidents and (case based) follow-up reports by the municipality are made available to the public as open data (CIBG, 2018b).

2 Methodology

This study uses an instrumental case study design (Stake, 1995), based on the FMS OGD. A novel dashboard is proposed that allows to assess the data quality of the FMS OGD and evaluates this data using the eight Sebastopol principles. The construction of this dashboard involved a series of procedures, starting from the data collection, data structuring to the development of the dashboard.

2.1 Data gathering

Three distinct Application Programming Interfaces (APIs) were used. An API works according to a set of predefined rules that explain how a third-party application can retrieve data from a host application. It is an intermediate layer that processes data transfers without offering insight in the business logic behind this process. This set-up ensures that, while data is exchanged, internal procedures remain shielded.

To leverage the FMS OGD, the platform's API was used. While the API was not made available to the public until 2018, historical data since the introduction of FMS is accessible. 171.185 incident reports were collected from Feb. 12, 2013 until Dec. 31, 2021. These incidents were associated with 560.587 interactions between citizens and public servants.

Since the FMS data contains Belgian Lambert coordinates for the localization of incidents, the Google Geocoding API was used to convert addresses to latitude and longitude (Google, 2022a). This simplified the plotting of incidents on interactive maps via the Google Maps API (Google, 2022b).

2.2 Data structuring

The JSON data, provided by the FMS API, is already structured and machine processible. Therefore, parsing and storing the data resulting from the FMS and Google GeoCoding API in a normalized MySQL database was straightforward. This was done via a Python 3.10 script. Since the parsed data did not contain the original language of the incident report, langdetect was used to detect and add the language when the incident was reported in textual format (Shuyo, 2022). Additionally, a Python script was used to obtain the district associated with each incident report via the Brussels' 'Wijkmonitor' form (BISA, 2022).

2.3 Data analysis

To explore the data in this case study, an extensible digital dashboard was designed. The dashboard supports all elements to apply the Sebasopol principles to the FMS OGD but is constructed to allow additional features for data analysis. The application was developed using the Flask web framework (Ronacher, 2010), following an Model-View-Controller (MVC) design that offers extensibility through modularity, and separates the internal logic from the way information is presented to and accepted from a user. This set-up allows on-the-fly exploration of the machine processed data and presents it in a human readable format.

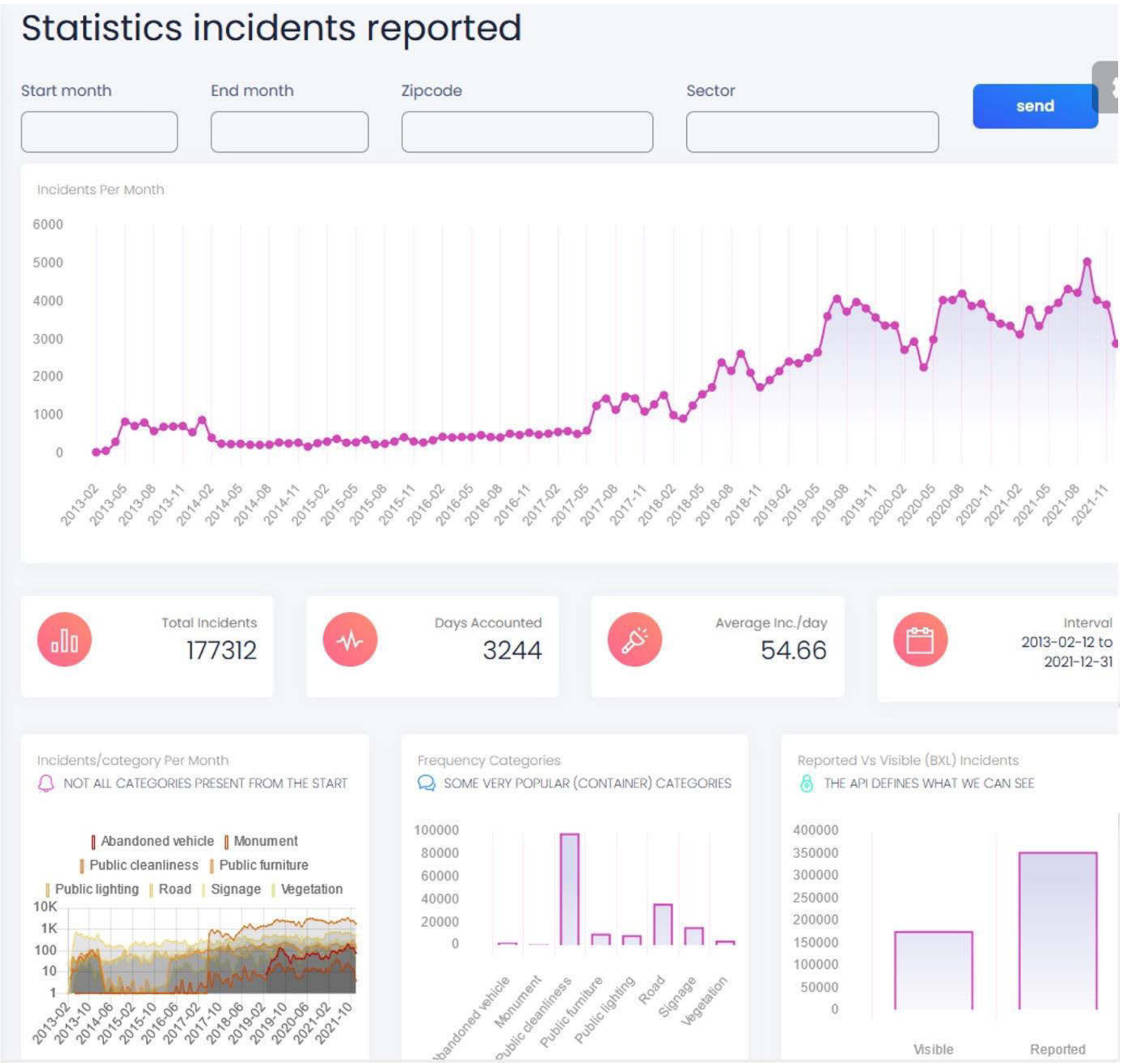

Figure 9: Overview of general data in the dashboard based on FMS OGD

The prototype dashboard has four main sections: the first part presents an overview of summarized data in FMS (Fig1). This includes the number of incidents per year, the distribution of incidents over the years, the average number of incidents, etc. It is possible to filter based on district, time interval or zip code. A second page presents the localization of incidents (Fig. 2). It is possible to filter per incident and set the granularity of the representation (heat maps, per sector, or at street level). The third page offers insight in the handling of incidents by municipal services. It is possible to check what incidents are handled by which public service, to compare the handling time per public service and/or district or to get a summary of the open and closed incidents, as well of the incidents being processed. Filters can be applied based on year, zip code and district. Finally, the fourth page allows users to search the open data. Text search is possible, as well as filtering on zip code, district, main and/or sub-category of the reported incident.

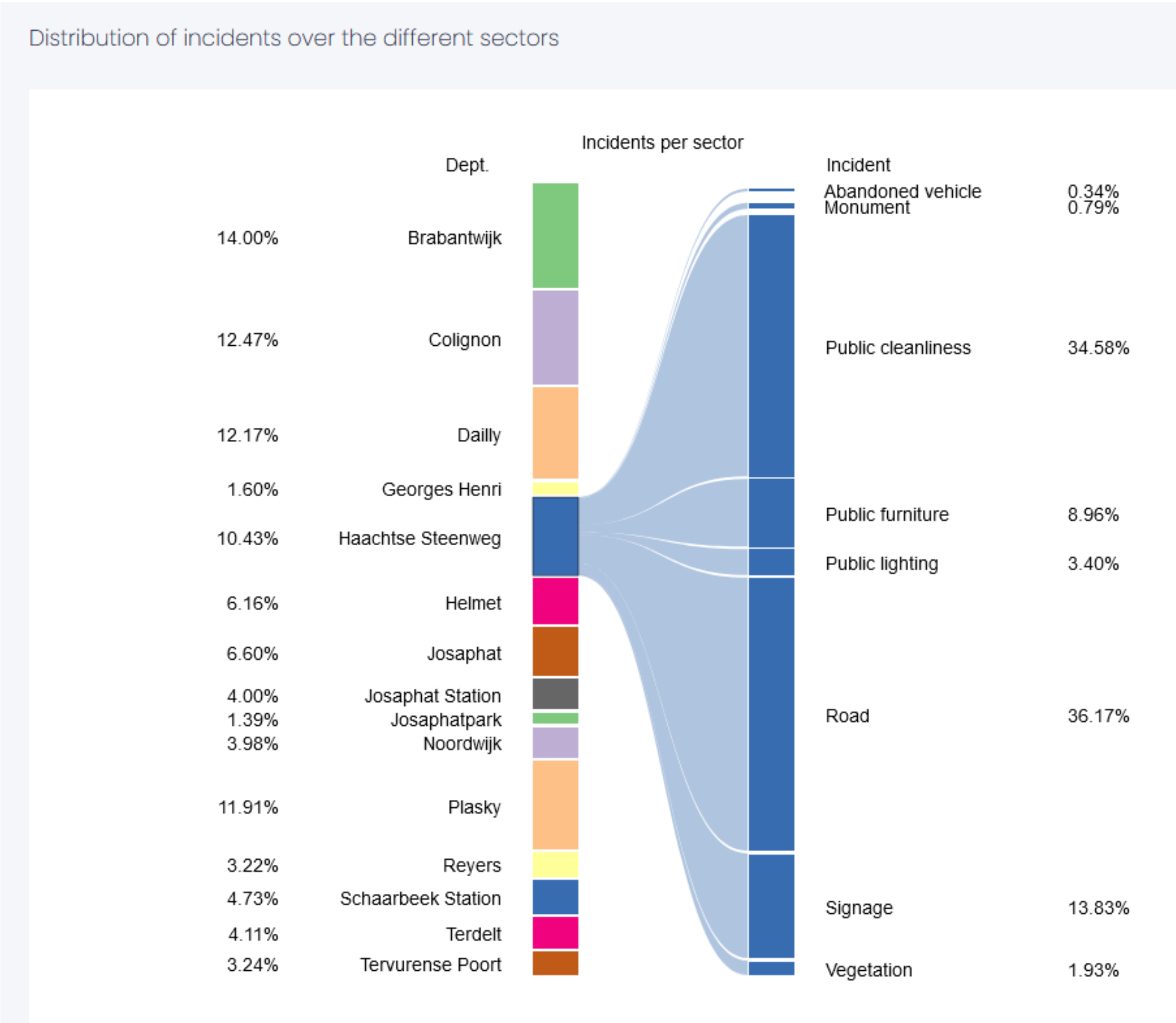

Figure 10: Detailed view of incidents per district in a municipality

3 Results and analysis

3.1 Complete

The completeness principle states that data should be open by default. However, data can be concealed, for example for privacy or security reasons. In these cases, the rationale behind hiding specific elements in the data should be transparent. Transparency is what allows citizens to see what and why actions are taken by the government. This principle breaks with the traditional way that a government interacts with its citizens. OGD builds on the presumption of publication for all, whereas traditionally a citizen had to ask public servants for the desired information. When data is not published, governments should justify why this data was obscured.
When reviewing the FMF OGD, a total of 171.185 incident reports were collected through the FMS API. All reports are uniquely identified by an incremental key. However, verifying the key of the last incident reveals that by Dec. 31, 2021, a total of 354.868 incidents had been reported since the activation of FMS in 2013. Hence, only 48,24% of all reported incidents are visible.

It is obvious that some type of selection is taking place and selection always equals data bias. An API allows a data provider to restrict access to the data, without delivering insight into the rationale behind this decision. As documented by the 'Centrum voor informatica van het Brussels Gewest' (CIBG), the data wasn't open to the public until 2018 (CIBG, 2018b). 'Openness' was conceived as an 'afterthought', a step taken five years after the application was implemented. Whereas a 'transparency-by-design' approach, that starts with 'outlining the objectives and what should be accomplished using transparency' (Janssen et al., 2017), this 'transparency-as-afterthought' seldom results in the desired level of transparency and understanding by the public since data is often 'patched' together without a clear vision and conceptualization of 'transparency'.

There can be good reasons for hiding data. OGD should be, for example, GDPR compliant. A general statement is found under the FAQ section on the FMS website claiming that incidents might be refused when (1) the incident does not concern a problem that has to be verified, (2) the incident was reported already, (3) the incident falls out of the scope of FMS, or (4) the content is abusive or illegal (Brussels Mobility, 2022). However, a closer inspection of the data through the dashboard's search module reveals that the data contains quite some citizens' private information. Search strings starting with '0475', '0486' (prefixes of Belgian mobile numbers) return mobile numbers of citizens with associated private information (name, address, etc.). Furthermore, the search string 'immatric' ('immatriculé' and 'immatriculation' refer to license plates) unveils several incident reports of littering where a citizen mentions the license plate of the offender. Other incidents are visible but were closed stating that the incident falls out of the FMS scope or state that an incident was reported already. Additionally, duplicate notifications of incidents were found. These reports seem to contradict the FAQ and since a clear data policy is lacking, it is difficult to pinpoint why specific incidents were hidden. The disclaimer relaxes the ambition to offer complete data even further:

"[…]it does not guarantee the adequacy, accuracy or completeness of such information or warrant that the above-mentioned website shall be continually complete and up to date in every respect. The information on this web portal may include inaccuracies of content, technical inaccuracies or typographical errors"

Without a clear data policy, it is opaque who is responsible and accountable for the data. Furthermore, there is no guarantee of the accuracy or the quality of the data. It is however apparent that only a fragment of the gathered data is available as OGD, and that this data is not GDPR compliant.

3.2 Primary

OGD should be primary. It is collected at the source, and unmodified. A primary data source offers a first-hand account of an event. Secondary sources are already one step removed from the initial observer and can introduce bias or distort the original observation. Primary data is therefore considered more reliable and authentic.

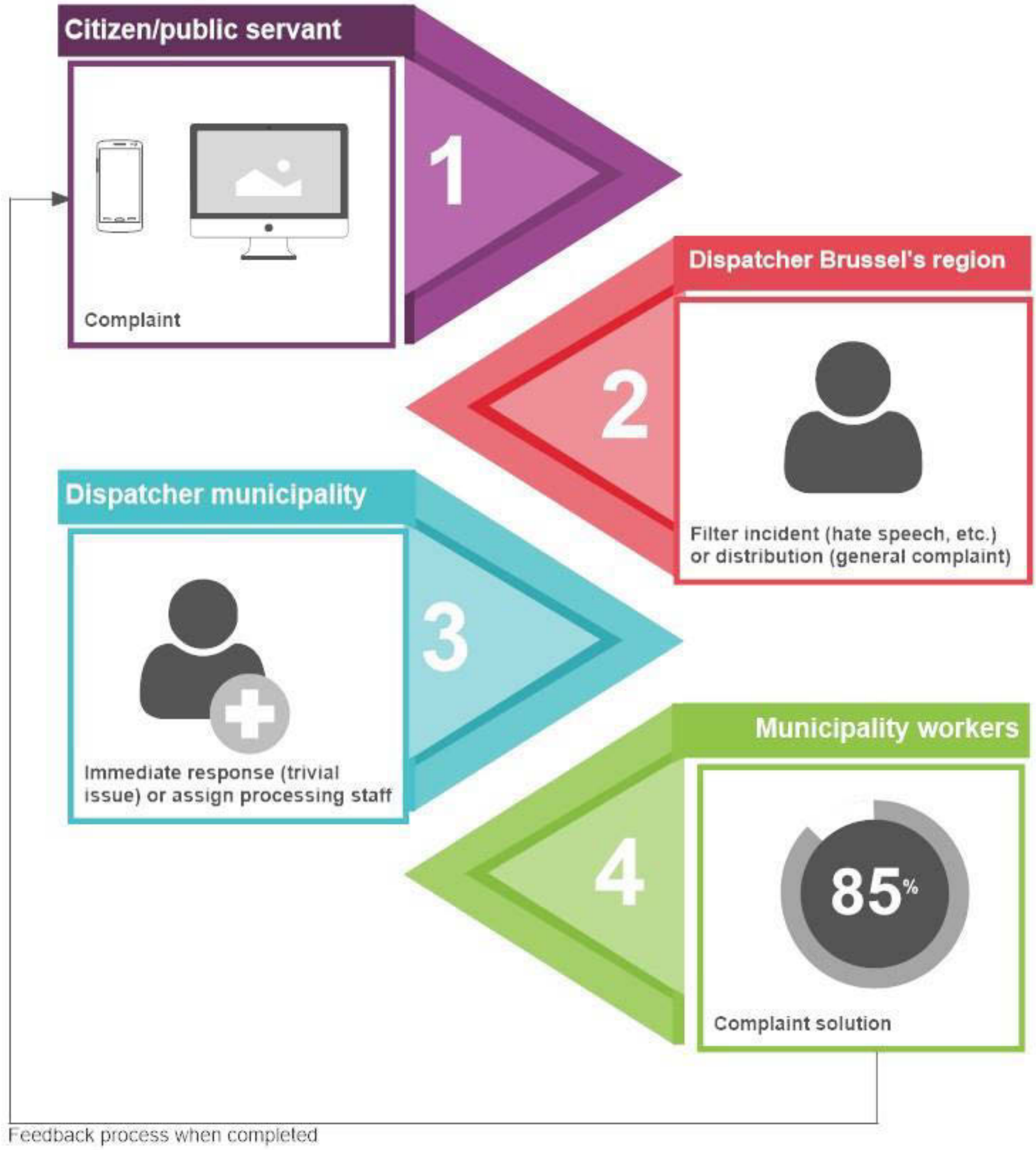

Figure 11: Communication flow triggered by an incident report in FixMyStreet (Steenhout et al., 2020)

To understand why the data is not primary, it is important to grasp the communication flow triggered by an incident report. Events can be an incident reported by a FMS user, or an action undertaken by a municipal service to solve an issue. The process from reporting an issue to resolving it, takes four steps (Fig. 3). First, a reporter can locate the problem on a map and add a text and/or picture describing the situation. The messenger does not need to worry which service is responsible. Based on the location and categorization of the incident, the incident will be filtered or directed to the correct municipality by the dispatcher at the Brussels' Region. In the next step, there is a back-end dispatcher at the municipality handling the incoming messages. This dispatcher decides what incidents will be handled and dispatched further. Some incidents are trivial in nature and can be answered and closed directly. If this is not the case, the incident will be forwarded to the department responsible, where the department manager will assign staff to the issue to solve the problem. And finally, when the issue is solved, the user is informed on the progress.

Table 5: Handling time per service for a Brussels' municipality. Only services that handled more than five incidents over the observed interval were included. (*) Total of all closed incidents in the municipality.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean: Lower Bound	95% Confidence Interval for Mean: Upper Bound
MIVB	87	416.80	602.903	64.638	288.31	545.30
Regional Dispatching	1679	147.31	392.349	9.575	128.53	166.09
Mobiris	383	102.69	211.116	10.788	81.48	123.90
Sibelga (lighting)	372	108.00	308.518	15.996	76.55	139.45
Net Brussels Group	**1276**	**.00**	**.000**	**.000**	**.00**	**.00**
Service Public Lighting	63	176.89	508.382	64.050	48.85	304.92
Municipal Roads - Dispatching	5223	49.44	198.430	2.746	44.05	54.82
Total*	9096	69.64	255.636	2.680	64.39	74.89

There is a potential conflict between the several steps to handle an incident and the principle of primary data. This becomes apparent when the actual handling time of incidents per service is analyzed. To illustrate, the closed incidents within a specific municipality in Brussels were analyzed for the interval 2013-2021.[39] Table 1 demonstrates an expected pattern for public services: a significant mean handling time for most services since outliers can be expected as several incidents will take considerable time to solve (e.g. fixing a pothole), whereas others can be fixed rather quickly (e.g. removing litter). This is also illustrated by the high standard deviations and, subsequently, the wide 95% CI for the mean. There is one exception, however. The data suggests that Net Brussels Group (cleanliness service for Brussels) is a highly performant service that manages to handle all 1276 incidents the same day of the incident report. The municipality was requested to provide insight into this phenomenon. The handling time visible in the FMS OGD is not the actual handling time of incidents by Net Brussels Group. Instead, this service does not work with FMS

[39] We opted not to name the municipality since this is not relevant as this text is not meant as a performance measure of municipalities, but instead wants to contribute to a better service of all municipalities using FMS.

and requested to close the incidents immediately. It was suggested that the service is highly performant and is usually aware of the problem before it is signaled in FMS. This strategy was not used in all municipalities. In several other municipalities, for example, the incidents regarding Net Brussels Group were closed by other services after a while. This introduction of automated handling of incidents, or closure by third parties, does introduce significant bias and no longer provides correct information to the citizen that reported these incidents. When a report for this service is filed, the signaler will be informed that the situation was handled while there is no guarantee of a (prompt) intervention at all.

Other types of automated messages were found that obscured the nature of the intervention, such as the notification that a report was being communicated to a specific service and consequently closed. In these cases, no detailed follow-up of the incident was possible. Incidents for several services were closed on behalf of a third, and hence non-primary, party, without guarantee that the closure time reflected the actual time to handle the incident or without detailed information on the interventions.

3.3 Timely

OGD has the potential to inform citizens and bridge the gap between citizen and, in this case, municipality by providing quick and correct feedback. This aligns well with the third Sebastopol principle, stating that data should be available as quickly as possible to preserve the value of the data. Ensuring that information is published fast increases the success of the application.

Apart from the previously described observation that not all reported incidents are visible in the FMS OGD, visible incidents are published without significant latency. We retrieved the data at 5 moments in time and each time incidents from the same day were already present. Incidents contain a timestamp for each intervention. This does not only inform citizens on a specific incident’s status via the FixMyStreet data, but also allows third-party developments, based on the FMS OGD, to filter relevant data. If an application, for example, wants to offer an overview of the current incidents in a specific area it can focus on relatively recent incidents.

Inspecting the incidents that were being processed in a specific Brussels’ municipality, however, triggered a red flag. While the vast majority of visible incidents were being handled by the services involved, none of the incidents that should be handled by the

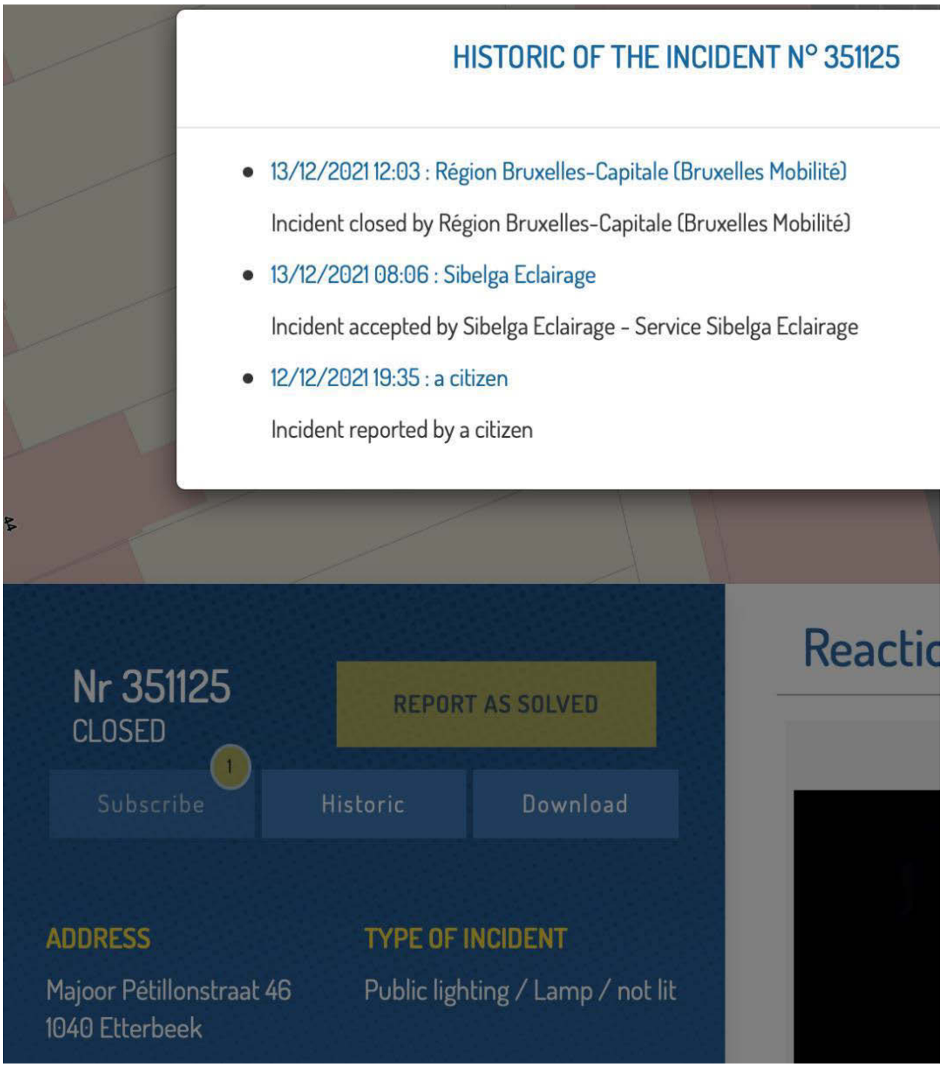

Figure 12: Citizen's report with 'track record' of interventions

service for community guards, nor the service Green Spaces, were closed between 2013 and 2022. After inquiry at the municipality, it became clear that the services intervened but worked with parallel systems to trace their interventions. These systems did not synchronize with the FMS application, leaving citizens in the dark. Reports kept the status 'processing' while, in fact, the issue might have been solved already.

Another issue relates to the use of standardized messages. Quite a lot of incidents mention that the 'incident has been closed by' a specific service. However, no information is given on the nature of the intervention. Fig. 4 illustrates the problem: a citizen reports that an area is not being lit. The next day, this issue is accepted by the service that handles lighting issues (Sibelga) and within 4 hours, another service closes the incident. The issue is flagged as 'solved', without mentioning the intervention made. This introduces ambiguity and leaves room for interpretation: Was this considered a non-issue and therefore closed after only 4 hours by another service, was it a matter of replacing light bolbs, was there a power failure in the street, or did Sibelga install new light lamp posts? As argued by Attard et al. (2015), success of an OGD initiative should "not only be evaluated on the amount of data published, but also on the usability of this data". The mere mentioning of an intervention, void of context, does not guarantee transparency, nor does it bring accountability. The strength of OGD is in providing real content of value to citizens.

3.4 Accessible

Everyone should be able to use, reuse and redistribute the OGD. There can be no discrimination against private persons, nor public or commercial entities. Allowing reuse and redistribution for academic or non-commercial use only is prohibited. Furthermore, the data can be used for the widest range of purposes.

The FMS OGD is, in principle, available to the widest range of users. While this looks like an appealing realization, in practice obtaining ‘access’ is more challenging. Access to data is governed by a ‘digital divide’, or the gap between citizens with access to ICT’s and those who do not. Additionally, it is also driven by a ‘data divide’ between citizens that have access to data and those who do not (Gurstein, 2011). Unlike bulk data that is easy to download, the use of the FMS API is limited to the rather tech savvy citizens. Furthermore, when the data can be retrieved, capitalizing on FMS OGD through additional analysis or linking the data with other data sources is quite complex. Developing new innovative technologies on the backbone of this data stays the privilege of software developers and will therefore be dependent on the interest and envisioned solutions of these developers. These solutions might not match the needs of citizens, nor complement services of the municipalities. Additionally, since the previous Sebastopol principles were not fulfilled, there is no guarantee on the quality of the data. The data is clearly incomplete and lacks important contextual information on the interventions. This limits the range of ‘purposes’, since inaccurate data will inevitably lead to inapt analysis or innovations (‘garbage in, garbage out’ principle).

3.5 Machine processible

The FMS OGD complies with the 5th Sebastopol principle: all incident related info is provided in JavaScript Object Notation (JSON) format by the FMS API. JSON is a lightweight data-interchange format that is easy for machines to generate and parse. It allows conversion to different data formats that allow in-depth exploration of the data. Furthermore, JSON promotes interoperability: it enables the linkage with other data sources and therefore increases the potential of developing new and better services on top of the FMS OGD.

3.6 Non-discriminatory

The 6th Sebastopol principle states that data should be available to anyone, with no requirement of registration. Considering that an API can introduce selection bias, the data that is offered by the API can be retrieved by everyone. The use of API is also documented and does not require a login, nor registration (CIBG, 2018a).

3.7 Non-proprietary

According to the 7th Sebastopol principle, data should be available in a format over which no entity has exclusive control. The FMS API serves data in a JSON format that is non-proprietary and released under an open license granting the use by everyone without any restrictions and at no cost.

The syntax is straightforward and does not require a specific program to explore its contents. JSON files can be opened in any text editor, without conversion, and the majority of programming languages support JSON. This setup guarantees that the format will not become out of date over time, nor that costs will be charged in the future to read these JSON files.

3.8 License free

The FMS OGD is available free of charge and under an open license. Therefore, it complies with the last Sebastopol principle. The data can be used to improve municipal performance but may also be used for commercial goals. It is thus allowed to make money out of the freely available FMS OGD by developing additional services.

4 Discussion

The Sebastopol principles are considered the corner stone for adequate access to OGD. In this paper the FMS OGD was scrutinized and juxtaposed with the Sebastopol principles. The data satisfies 3 principles: (1) it is machine processible, (2) the access is non-discriminatory since it does not require login, nor access fees, (3) the data is presented in a non-proprietary format and (4) is offered license free.

Other issues encountered related to the remaining four Sebastopol principles: (1) With less than 50% of the incidents visible, the data was obviously not complete. (2) Third parties sometimes close incidents on behalf of the responsible department or vague and ambiguous automated messages are used in response to incidents. This leaves the reporting and consulting citizens in a state of uncertainty. It is often unclear what type of, if any, intervention took place. Additionally, (3) since third parties can close incidents (sometimes several months later), the actual time of the intervention is unclear. This introduces additional bias in the data. Furthermore, the principle of accessibility is not satisfied. The quality of the data is unknown and can therefore lead to inapt solutions: poor data to start from, results in poor analysis that might lead to wrong prioritizations. It is also worth mentioning that providing OGD solely through an API limits access to the rather tech savvy sample within a population. In addition to the well-documented digital divide, this tends to create an additional data divide.

The ‘open’ character of OGD is remarkably often framed as translating the existing data and/or communications to a digital format. In the case of FMS, for example, there already was a ‘hotline’ available to signal incidents by phone. These notifications triggered interventions as well and left a paper trail. Today, this hotline still co-exists with FMS and is illustrative of the interpretation of ‘openness’. Notifications in FMS leave a digital trace and, unless the incident is obscured by public services, can be consulted via the platform or the API. Openness can also be interpreted more broadly however: it shouldn’t be limited to providing data, but should be about “claiming access to knowledge and information” hidden behind gateways created by public resources (Shah, 2013). Transparency does not only depend on ‘technology solutionism’, or the incorrect belief that technology itself promotes transparency (Morozov, 2013). Effective use of OGD is ensuring that this data is translated into outcomes available to the widest range of citizens and ascertain that those who need it most are reached as well. Rationale behind the principle of accessibility is that the data should empower everyone. It could be argued, however, that access is mostly restricted to those who have access to the technology and the necessary technological and analytical skills to optimally extract information from the provided data. As argued by Gurstein (2011) “this would then suggest that a primary impact of ‘open data’ may be to further empower and enrich the already empowered and the well provided for. On the other hand, those most in need of the benefits of such new developments may find themselves out of luck”.

While it is quite possible that incidents with abusive content, redundant notifications or privacy issues are – as stated in the terms of use - withheld from the data. Janssen et al. (2012) argue that public services only tend to publish data that are not sensitive, not very complex, or can do no harm. Upon inspection of the data, however, we did find quite some content that was not GDPR compliant. Without a clear data policy, it is impossible to assess the quality of the data.

The lack of a policy leaves room for tinkering with the data. In extreme cases, this might even lead to the opposite of what open data is trying to achieve. Instead of creating more transparency and a more just and equitable society, the use of APIs introduces the possibility of gatekeeping. Without a clear data policy, citizens are oblivious to the selection processes that take place behind the scenes. In extremis, only incidents and interventions that support a certain agenda might be published, whereas incidents that contradict this agenda might be obscured. It also leaves room for discrepancies between municipalities. Some municipalities might decide to open up more incidents to the public than others. A perverse effect might be the ‘mislabeling’ of certain areas as ‘problem areas’ simply because less incident reports are obscured. Shah (2013) warns that we cannot “ignore the politics of data themselves, what the data reveals, or how they are used and for whose interests”. APIs can be extremely useful, but also put a lot of power in the hands of the data publisher. This, in turn, can – in the worst case - open the door for abuse and corruption. Fragmented data results in misinformed citizens and policymakers and thus introduces serious risks in the supposedly data-enriched citizen/government relation. Inaccurate or incomplete data might lead to misguided policy recommendations, misplaced funding and a complete misunderstanding of the situation.

Furthermore, once citizens realize that data can be tinkered with, this can backfire and create further mistrust in the public sector. Full comprehension requires a clear data policy that foresees in detailed context on actions taken by public servants, and if reports are withheld from the public, this should be justified. After all, openness is not limited to opening up fragments of data, it should also create clarity on the removal of content.

5 Conclusion

While there are no indications of malicious intent, this study reveals some disturbing facts about the FMS OGD. Despite the numerous efforts to invest in quality OGD by the Brussels Capital Region, some conditions and good practices to provide quality data are not met. Furthermore, the open data proved to be non-GDPR compliant. These concerns should be addressed. Citizens should be able to trust that the open data is accurate, fair and at the same time will not compromise their privacy. A clear data policy can deliver insight in the data that is made available to the public and should justify why some parts are kept closed, while better moderation – assisted by automated detection of private information - should guarantee GDPR compliance. A coordinated approach and clear strategy will be needed to fix these issues. We do recognize that OGD is still at its infancy and will continue to evolve and improve.

This paper identified the gaps in the existing FMS OGD and therefore contributes to a better understanding of steps that should be taken to provide a better service to citizens and to create more opportunities to build on the available OGD. These findings allow the Brussels Capital Region to address these issues and deliver improved OGD in the future.

As proposal for improvements and future work, we aim to further develop the dashboard and extend it with needs-based views that – through a user centered – approach will translate the data to meaningful output for the different types of users. Additionally, further research is needed to address the needs of citizens that do not have access to digital infrastructure. This should prevent that the exciting outcomes expected from OGD - once it reaches its state of maturity - are available for the widest range of citizens.

References

ASHLOCK, P. 2013. The biggest failure of open data in government [Online]. Open Knowledge foundation. Available: https://blog.okfn.org/2013/03/15/the-biggest-failure-of-open-data-in-government/ [Accessed May, 8 2022].

ATTARD, J., ORLANDI, F., SCERRI, S. & AUER, S. 2015. A systematic review of open government data initiatives. Government Information Quarterly, 32, 399-418.

AYRE, L. B. & CRANER, J. 2017. Open Data: What It Is and Why You Should Care. Public Library Quarterly, 36, 173-184.

BISA. 2022. De Wijkmonitoring van het Brussels Hoofdstedelijk Gewest [Online]. Available: http://http://wijkmonitoring.brussels/locate-sector/ [Accessed May, 8 2022].

BRUSSELS MOBILITY. 2022. FixMyStreet.Brussels: Frequently asked questions (FAQ) [Online]. Available: https://fixmystreet.brussels/faq [Accessed May, 8 2022].

CIBG. 2013. FixMyStreet.Brussels: Meld problemen in de Brusselse openbare ruimten [Online]. Available: https://fixmystreet.brussels [Accessed May, 8 2022].

CIBG. 2018a. API for developers with Smart City [Online]. Brussels: Brussels Smart City. Available: https://api.brussels/store/apis/info?name=fixmystreet&version=1.0.0&provider=admin [Accessed May, 8 2022].

CIBG. 2018b. FixMyStreet now available as Open Data [Online]. Bussels: CIRB. Available: https://smartcity.brussels/news-570-fix-my-street-now-available-as-open-data [Accessed May, 9 2022].

GOOGLE. 2022a. Google Geocoding API [Online]. Available: https://developers.google.com/maps/documentation/geocoding [Accessed May, 8 2022].

GOOGLE. 2022b. Google Maps API [Online]. Available: https://developers.google.com/maps [Accessed May, 8 2022].

GURSTEIN, M. 2011. Open data: Empowering the empowered or effective data use for everyone? First Monday, 16.

HABIB, A., PRYBUTOK, V. & PHILPOT, D. 2022. Assessing and building municipal open data capability. Information Systems and e-Business Management, 20, 1-25.

HARRISON, T. & SAYAGO, D. 2014. Transparency, participation and accountability practices in open government: A comparative study. Government Information Quarterly, 31, 513-525.

HUIJBOOM, N. & BROEK, T. V. D. 2011. Open data: An international comparison of strategies. European Journal of EPractice, 12, 4-16.

JANSSEN, K. 2011. The influence of the PSI directive on open government data: An overview of recent developments. Government Information Quarterly, 28, 446-456.

JANSSEN, M., CHARALABIDIS, Y. & ZUIDERWIJK, A. 2012. Benefits, Adoption Barriers and Myths of Open Data and Open Government. Information Systems Management, 29, 258 - 268.

JANSSEN, M., MATHEUS, R., LONGO, J. & WEERAKKODY, V. 2017. Transparency-by-design as a foundation for open government. Transforming Government: People, Process and Policy, 11, 2-8.

JANSSEN, M., MATHEUS, R. & ZUIDERWIJK, A. Big and Open Linked Data (BOLD) to Create Smart Cities and Citizens: Insights from Smart Energy and Mobility Cases. In: TAMBOURIS, E., JANSSEN, M., SCHOLL, H. J., WIMMER, M. A., TARABANIS, K., GASCÓ, M., KLIEVINK, B., LINDGREN, I. & PARYCEK, P., eds. Electronic Government, 2015// 2015 Cham. Springer International Publishing, 79-90.

JEFFERSON, B. 2020. Digitize and punish: racial criminalization in the digital age, Minneapolis, University of Minesota Press.

LAURIAULT, T. & FRANCOLI, M. 2017. Openess, transparency, participation. In: KITCHIN, R., MCARDLE, G. & WILSON, M. (eds.) Understanding spatial Media. London: Sage.

LESSIG, L. 2017. Ten principles for opening up government information [Online]. Sunlight Foundation. Available: https://sunlightfoundation.com/policy/documents/ten-open-data-principles/ [Accessed April, 16 2022].

MÁCHOVÁ, R., HUB, M. & LNENICKA, M. 2018. Usability evaluation of open data portals. Aslib Journal of Information Management, 70, 252-268.

MALAMUD, C., O'REILLY, T., ELIN, G., SIFRY, M., HOLOVATY, A., O'NEIL, D. X., MIGURSKI, M., ALLEN, S., TAUBERER, J., LESSIG, L., NEWMAN, D., GERACI, J., BENDER, E., STEINBERG, T., MOORE, D., SHAW, D., NEEDHAM, J., HARDI, J., ZUCKERMAN, E., PALMER, G., TAYLOR, J., HOROWITZ, B., EXLEY, Z., FOGEL, K., DALE, M., HALL, J. L., HOFMANN, M., ORBAN, D., FITZPATRICK, W. & SWARTZ, A. 2007. 8 Principles of Open Govenment Data [Online]. Sebastopol: Open Government Working Group. Available: https://public.resource.org/8_principles.html [Accessed May, 8 2022].

MEIJER, A., CURTIN, D. & HILDEBRANDT, M. 2012. Open government: connecting vision and voice. International Review of Administrative Sciences, 78, 10-29.

MOROZOV, E. 2013. To save everything, click here: technology, solutionism and the urge to fix problems that don’t exist, London, Pinguin Books.

RONACHER, A. 2010. Flask: Web development, one drop at a time [Online]. Available: https://flask.palletsprojects.com/en/2.1.x/ [Accessed May, 8 2022].

RUIJER, E., GRIMMELIKHUIJSEN, S., BERG, K. C. D. & MEIJER, A. 2020. Open data work: understanding open data usage from a practice lens. International Review of Administrative Sciences, 86, 3-19.

SHAH, N. 2013. Big data, people's lives, and the importance of openess [Online]. Connected Learning Alliance. Available: https://clalliance.org/blog/big-data-people-s-lives-and-the-importance-of-openness/ [Accessed May, 8 2022].

SHUYO, N. 2022. Langdetect: a language-detection library for Python [Online]. Available: https://pypi.org/project/langdetect/ [Accessed May, 8 2022].

STAKE, S. E. 1995. The art of case study research, London, Sage Publications Ltd.

STEENHOUT, I., VOLINZ, L., BEYENS, K. & MELGAÇO, L. 2022. The long road to Municipality 2.0: mobile city apps as catalyst for change? Brussels: Vrije Universiteit Brussels.

STYRIN, E., LUNA-REYES, L. & HARRISON, T. 2017. Open data ecosystems: an international comparison. Transforming Government: People, Process and Policy, 11, 132-156.

ZUIDERWIJK, A. & JANSSEN, M. The negative effects of open data: investigating the dark side of open data. 15th Annual International Conference on Digital Government Research, 2014 Aguascalientes Mexico. Association for Computing Machinery, 147-152.

Inclusion and exclusion in citizen science: A matter of context

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Abstract. Associated with promises of inclusion and sometimes the democratisation of research processes, citizen science is a highly normatively charged term. These promises often go hand in hand with the optimistic claim that citizen science is per se anti-elitist and anti-traditionalist and stands for openness, civic education – and indeed inclusion. Inclusion is a frequent topic of critical discussions among those who publish on citizen science. This paper argues that for several reasons these promises are far from being self-evident. First of all, citizen science is not a clear-cut, well-defined concept. Secondly, it is also not clear what inclusion in citizen science activities means if it is discussed on a too general level. Which forms of inclusion and exclusion citizen science can produce depends on the respective citizen science activities and their dimensions, i. e. conditions these activities depend on. These forms have to be known to assess if an activity should be inclusive. For their Activities & Dimensions Grid of Citizen Science, which is based on a very broad description of citizen science by European Commission, the authors roughly grouped citizen science activities into four areas: citizen science in 1) science policy, 2) scientific research, 3) development and innovation, and 4) school education. In this paper the authors describe for each area exemplarily, how inclusion and exclusion may happen. Furthermore, they argue that inclusion is not an end in itself and not an important aspect of every citizen science activity.

1 Citizen science – not a clear-cut concept

"Inclusion in citizen science" - this immediately raises several questions: what is citizen science? What is meant by inclusion? And finally, what is inclusion in citizen science? Let us start with citizen science. Originally, Alan Irwin (1995), in his book with the same title, used this term to describe a form of science that takes societal concerns seriously and addresses them in a democratic exchange with citizens. At about the same time, the Cornell Ornithology Lab coined the term “citizen science” as a kind of participatory science. Significantly later than Irwin and the Cornell Ornithology Lab began to use it, the term “citizen science” has gained prominence as a search term since at least 2015, according to a Google trend analysis, and it is reasonable to assume that this term is beginning to outrank, if not successively replace, the term "public engagement in science", a Google trend analysis suggests. It is not always clear what citizen science is. There are dictionary definitions of the term, according to which citizen science is characterised by the fact that volunteers participate in research projects, for example by announcing plant or animal observations (e.g., OED, n. d.; Lexico, n. d.). For others, this concept of citizen science is not broad enough. For them, it also includes the formulation of research questions, participation in research policy decisions, projects of a research nature in schools or even amateur science. The description of citizen science published by the European Commission in the work programme Science with and for Society (European Commission, 2018) includes all of them: the scientific auxiliary activities of volunteers, the co-design of research projects by citizens, so-called amateur science, science education in schools, science communication in the sense of outreach activities and the participation of citizens in research policy.

2 Inclusion as a topic of discussion in citizen science communities

In a nutshell, there is no definition or explanation of citizen science on which those involved in citizen science can agree unanimously; indeed, they do not even agree on whether such a definition or explanation is necessary. Which brings us to the middle of debates about the inclusivity of citizen science. While Heigl et al. (2017 & 2019) argue that a common understanding of what constitutes citizen science is necessary for the acceptance of citizen science in scientific communities, Auerbach et al. (2017) argue against it because they fear that a definition of citizen science might exclude some forms of citizen participation in research processes from being considered citizen science. According to them, to remain as inclusive as possible, there should be no binding definition of citizen science. In citizen science communities there are also debates about the inclusivity of citizen science via terminology debates, in which the term "citizen" is primarily problematised (e.g., Eitzel et al., 2017). Who is addressed by "citizen"? How should participants in citizen science activities be referred to in an appreciative way? Are "layperson" and "volunteer" derogatory terms? These are questions that are being asked and discussed in detail. However, in all these debates there is no discussion about whether the term "science" is the right one at all, as if there were no questions about what is meant by it. The question is who is engaging in these debates. Apparently, these debates are mainly led by scientists. In her study, Tancoigne (2019) has found that on Twitter organisers of citizen science activities and media reporting about them persistently used the terms "citizen science" and "citizen scientist" as a brand name, so to speak, but many of the other participants did not. It would require additional research to find out why that is so. (For a detailed discussion of these terminology debates, see Strähle & Urban (2021)).

Inclusion is at the core of the whole concept of citizen science, which defines itself by including people into research, who are usually not involved in it. The difficulty is to define an activity according to who is performing it. In the case of citizen science, “science” becomes “citizen science”, if done by non-professionals or if they contribute to it. But does science depend on who carries it out, or rather on what is done and how, if and what scientific protocols are applied, if the applied used methods are sound, the analysis is comprehensible, etc.? From a normative point of view, if a non-professional or an autodidact meets scientific standards, it is science. Conversely, formally trained scientists do not always perform sound research.

3 Promises of citizen science

Irrespective of all conceptual confusions surrounding citizen science, on its way up the totem pole of science policy it was supported by more or less unsubstantiated, but nevertheless strong promises what it can achieve. Strasser et al. (2019) group these promises into three themes: a greater democratisation of science, better scientific literacy, and new scientific breakthroughs" (p. 62). Kimura & Kinchy (2016) think that these promises create expectations that sometimes conflict with each other. Basically, it is largely unclear which promises of inclusion and democratic participation citizen science can keep. Since despite its increasing popularity, there has been little systematic research on who participates or wants to participate in citizen science projects (e.g., See, 2016; Pandya & Dibner, 2018; Füchslin et al., 2019; Burgess et al., 2017), however, according to Pandya & Dibner (2018), Haklay (2013), Füchslin et al. (2019) and Strasser et al. (2019) cumulative effects in favour of middle-class individuals are also likely to be evident in citizen science. Seen in this light, it is difficult to answer the question of how inclusive citizen science is. How, then, can we generally verify the promises of some proponents of citizen science with regard to inclusion and participation? Some of the reasons why citizen science cannot keep all its promises are conflicting expectations of and insufficient knowledge about who actually participates in citizen science activities and who benefits from these activities on the one hand, and on the other that the promises are quite general.

4 What could inclusion mean in citizen science?

As it is far from being clear what citizen science is, the question remains: what is inclusion? Generally speaking, aiming at inclusion in citizen science activities means that everyone who is interested in participating has the same chance to do so as all others who are interested. The participation of a broad range of people or socio-economic diversity of participants, even if there is empirical evidence for it, does not proof that an activity is specifically inclusive, although the opposite may be an indicator of non-inclusiveness. If participants in an activity are a relatively homogeneous social group, very often this can be taken as a proof that an activity is not inclusive, albeit with some exemptions, e. g. activities that are of interest only to representatives of a certain profession, who share also some socio-economic characteristics. The fact that homogeneity can be a strong indicator for the (open or hidden) exclusiveness of an activity should not mislead to believe that conversely inhomogeneity gives necessarily evidence for inclusiveness (Georgi, 2015). Firstly, we do not know if participants are “typical” for the social group to which they belong. Secondly, we do not know how many individuals from which social group would have liked to participate if they had the opportunity. Thirdly, groups of participants might be inhomogeneous in many respects but very homogeneous in the characteristics that are relevant for the activity. For example, a group of COVID-19 deniers can involve people of all genders, age groups, education levels, professional or cultural backgrounds, but it is very unlikely that all people are equally invited to join their collective endeavours, research-related or not.

In many cases it is not possible to tell if participant groups are homogeneous or not, because participants are not known to the organisers of a citizen science activity, for example, if they are allowed to participate anonymously, as is often the case in crowdsourcing (Pandya & Dibner, 2018, Strähle & Urban, 2021). Even if they are known, asking participants about their socio-economic backgrounds could create a barrier for participation and some/many organizers probably refrain from interrogating participants (too much).

Regarding inclusion/exclusion also organisational aspects could play a role. Depending which institution/s or person/s organises citizen science activities, other some groups of individuals may feel more comfortable or uncomfortable to participate than others. If citizen science is no exception to the common saying “birds of a feather flock together”, then one must be aware that any group of people who share interests or characteristics tend to exclude other groups, even if they have no intention to do so. For example, an initiative of environmental activists has probably difficulties to attract motorists’ initiatives for the expansion of the road infrastructure. Another issue is in what kind of activities participants are actually included, in which settings and how much power they have. When decisions are taken, for example on research topics and project design or, if research policies are discussed, how realistic it is that everybody has the same opportunities to have a say. Engaging professional facilitators might mitigate the effects of group hierarchies but they cannot fully prevent unequal inclusion.

The most obvious obstacle for equal inclusion is the unequal distribution of resources between citizens. When there is a lack of financial resources, there is often a lack of time resources as well. People who have to work hard to make ends meet are less likely to spend leisure time on volunteer activities. If no attention is paid to the uneven distribution of resources, inclusion can become selective, which calls into question demands that “citizens” should have as much influence as possible when involved in science endeavours to make citizen science as inclusive as possible. In such a case it is almost guaranteed that those who are already advantaged by education, time and financial resources become even more advantaged because their views and interests are promoted.

There is a contradiction in citizen science. On the one hand many scholars and practitioners claim that it is inclusive (e.g., Buytaert, 2014). At the same time there is some indication that most participants are members of higher or higher middle classes (although there is often no way to tell who the participants are) (Pandya & Dibner, 2018), Haklay, 2013, Füchslin et al., 2019, Strasser et al., 2019). Such a result would not be surprising, because these groups are more likely to possess sufficient resources for voluntary engagement or entertaining their interests and are more likely to have enjoyed an education that made them more interested in scientific topics. This tendency to exclude certain members of society because of their low resources and affinity to science, among other things, is deplored in literature (Dawson 2018):

> *„(…) (T)he field of citizen science is in danger of reproducing the inequities, biases, and underrepresentation that has plagued science. Our interpretation of available evidence suggests that the majority of projects that are being studied/profiled in the peer-reviewed scholarly literature have a participant base that is well-educated, middle to upper class, older in age, and almost entirely white." (Pandya et el. 2018, p. 44)*

Demanding for inclusivity relates to public funding also. If tax payers' money is invested in a citizen science activity, one can demand it gives something back to society. It makes a huge difference if a private club of hobby astronomers stays among themselves and purchases needed equipment with their own money, or if they apply for public funds to buy equipment. In the latter case inclusivity can be demanded as a condition for funding, in the first case, nobody can be forced to open up to the public.

5 Inclusion and exclusion - a matter of contexts

Which forms of inclusion and exclusion citizen can produce depends on the respective citizen science activities and their dimensions, i. e. conditions these activities depend on. And these forms have to be known to assess if an activity should aim at being as much inclusive as possible. Literature research shows that the term citizen science has become (or always was) too broad to allow for meaningful research and analysis in respect to shedding some light on its benefits, caveats, barriers, enablers and disincentives. The many activities performed by different groups of people under multiple possible conditions that are called citizen science need separate investigation. Building on categories, (non-)typologies, reflections on the sensibility or feasibility of such classifications by various scholars and their questions and demands, (Bonney et al., 2009; Cooper et al., 2019; Franzoni & Sauermann, 2014; Haklay, 2013; Haklay, 2018; Prainsack, 2014; Schrögel & Kolleck, 2018; Serrano Sanz et al., 2014; Shirk et al., 2012; Wiggins & Crowston, 2011; Wiggins & Crowston, 2012; Wiggins & Crowston, 2015) and complementing it by additional possible characteristics, the authors compiled a set of activities and dimensions to develop the Activities & Dimensions Grid of Citizen Science. The activities are grouped into four areas. The appropriate unit to

analyse citizen science is not a project, but an activity. Each activity within a project can show a different profile of characteristics.
In the following some areas of citizen science activities and some of their respective dimensions are regarded under the aspect of inclusion or exclusion.

5.1 Area 1 Input for research policy

Activities in these areas are not about doing research or innovation, but they are about decision-making in politics. Even if participants have no real political power, all deliberative formats can directly or indirectly influence political decisions. Citizen science in this area is a form of what is considered as participatory democracy by many policy makers; however, it is a term that is quite differently understood (Council of Europe, 2022, Abels, 2009).
In the following we do not talk about referenda but different formats in which “citizens” or “civil society” (sometimes civil society organisations are included) deliberate on political issues, such as citizen juries, consensus conferences, planning cells and scenario workshops. Such formats dealing with science-related issues have gained popularity and are now dubbed citizen science. Some formats have been developed and used in the context of urban planning. (Traces of this origin can be found in Arnstein’s “ladder of participation” (Arnstein, 1969), which was very popular among citizen science advocates. Hopes and concerns about participatory democracy in general are valid for participatory activities in research politics as for other fields of politics.
The field of citizen deliberation for policy making is still in an experimental phase and optimal formats have not been found yet. To avoid voluntary arbitrary selection, there is some experimentation with sortition, e.g., randomly selecting participants from a pool of people who fulfil certain criteria and/or are willing to participate and providing sufficient resources to make participation possible for those who normally could not afford to do so. Examples for citizen consultations are consultations on Cohesion policy organised by the European Commission (European Commission, 2022).
Even if it is decided by lot who participates in a deliberative event, i.e., is included in or excluded from deliberation, it is still the question how much financial support should be provided and in which form to make participation of less resourceful people possible. Remunerating travel costs and stay may not suffice. And even if sortition is applied and all necessary support is given to economically weaker participants, not all problems are solved. There remains potential strong influence on the outcomes by those who organise deliberative events: because of an organisers’ effect we postulate, as we suppose there is an effect caused by how an organiser of such deliberations is perceived by potential participants, the compilation of information material, the choice of facilitators, reporting and documentation, to name a few. There is still a long way to go to experiment with formats that could minimize such influences.

5.2 Area 2 Scientific research

This area comprises all activities in which non-professionals contribute directly to specific projects or initiatives by carrying out scientific or science-related tasks without being (substantially) paid for their work. Most of the contributors are volunteers, but of course one never can rule out hidden dependencies, group dynamics or power structures that could create (conscious or unconscious) pressure on individuals to participate. Caution demands to ask if (all) volunteers are included fully voluntarily in a specific project and to scrutinize it for any traces of involuntariness.

There is a broad range of activities that can be performed by untrained participants, and many categorisations, typologies or models distinguish forms of citizen science by the steps of research in which citizens are involved. Building on such models the Activities & Dimensions Grid of Citizen Sciences includes such a classification by activities (see Table 1).

Table 1: Citizen science activities (Strähle & Urban 2021)

Area 1: Research Policy	
Deliberation, consultation, etc.	*Inclusion of high importance.*
Area 2: Participating in research	
Determining research questions	*Inclusion of high importance.*
Research design	*Inclusion of high importance.*
Data collection	
Data preparation & processing	
Retrieval of scientific literature	
Experimenting	
Knowledge management	
Analysis & problem solving	
Reviewing & evaluating	*Inclusion of high importance.*
Action research	
Passive participation	
Area 3: Development & inclusion	
Technical development	
DIY biology	
Area 4: Citizen science in schools	
All activities in the Areas 1-3 are possible.	*Inclusion of high importance.*

Some authors even suggest that citizen science should involve citizens in all tasks of a project, often based on the assumption that data collection would be a very basic form of participation. For example, Haklay's elevator (Haklay, 2018), which is based on Kleijssen et al. (2017), presents a hierarchy of activity-based forms of participation in scientific projects. The idea behind this is that participation high on the elevator is more inclusive and desirable than in those low on it.

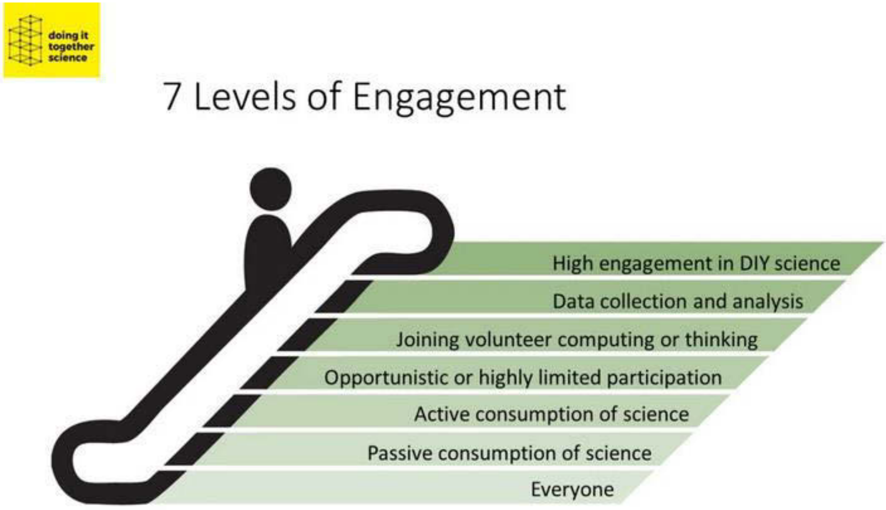

Figure 1: Escalator of engagement levels (Haklay 2018)

Put to extremes this approach says: The more the roles and the activities of the citizen scientists resemble those of the professional ones the better. We call this the strong idea of inclusive citizen science. The question remains who polices the boundaries between citizen and professional scientists. It can be fairly assumed that usually the professionals to police the inclusion of non-professionals. This version has to answer to some questions: Apart from being satisfied with having contributed to something participants consider as a meaningful activity, what can they gain from it? Does it have a positive impact on their lives and, even more important, on society as a whole? How much power do participants have to influence the research that is carried out? These questions are far from simple to answer. Most obviously, those participants are in a powerful role who have a say in the research questions. The same can be said about co-determining the project design. The possible influence in other activities vary largely. For example, although it may be true that many projects have participants performing seemingly easy tasks, like taking photos and sending them to the project owners, in many cases collectors of data need to be skilled and knowledgeable. Each of them can impact on the results of a research activity, sometimes profoundly, especially in small projects, for example, if they hold back information. (Pocock et al., 2017). If they conduct interviews, they can influence interviewees. Hence, one cannot generalise on inclusion but has to take the potential influence into account. If there is no substantial power for influencing a research project and participation in a project means that resourceful people donate their time without gaining more than personal satisfaction, why should it be problematic if people who do not possess sufficient resources are de facto excluded? The difficulty rather lies in determining if both conditions are met.

5.3 Area 3 Development & Innovation

The more recent addition of this area to the realm of citizen science broadens the concept considerably. This area includes development and innovation activities which can also take place in fab labs, DIY laboratories and hobby garages. Invention can take place in a wide range of fields: DIY Biology, usability testing, engineering, software programming, just to name a few. The motivation for participating is probably mainly rooted in making concrete products rather than in producing knowledge. The boundaries between reproduction of existing products and making something new may be difficult to draw, as both can happen side by side at the same locations (in fab labs, private laboratories, hobby garages, etc.). Because activities might result in new products or improvement of existing products, it can potentially lead to economic gain for some participants. This makes the question of inclusion to a question of just distribution, too. If public funding is involved, equal access to tools, infrastructure and technical support for all who want to innovate and develop can be asked for. It may be equally important to establish clear rules for any economic exploitation of innovation.

5.4 Area 4 School projects

School projects in citizen science are presented as a means to interest children in science & research, especially STEM disciplines, to increase the number of STEM graduates in fields for which a future demand of a high number of professionals is anticipated (Gough, 2015).

By some authors (e.g., Ruiz-Mallen et al., 2016), school projects with pupils are seen as more successful in involving participants with low education backgrounds and thus more inclusive than other projects. Irrespectively, if we are dealing with research policy making (area 1), participating in research or DIY activities, schools have (or should have) as a first goal to teach children according to a curriculum, who have a civic right to get as good an education as possible. Hence, in schools, citizen science becomes a didactic tool and inclusiveness has to be evaluated under this perspective. In case a specific citizen science activity with specific characteristics proves appropriate as a teaching method, it has to be asked if it works equally well for all participating children. Just being physically there does not yet prove that a child is included. It is also possible that pupils coming from highly educated families benefit more from some modern learning and teaching methods than pupils whose families have less affinity to education.

6 When is inclusion important?

Exclusivity can be more ethical than inclusivity, for example, if special skills are needed or longstanding trustworthiness has been proven by participants who are to operate in sensible biotopes, to handle fragile archeologic artefacts, deal with rare species, etc. If there is access to sensitive private data of other participants or if there is a potential risk for the physical or mental health of participants, the activity might not be appropriate for citizen science, require experts and demand for total exclusion of lay persons. Exclusion can be also more ethical, if an individual asking to participate has personal conflicts of interests, which is not a specific issue of citizen science but a problem that receives much attention in “traditional” research.

Where a citizen science activity takes place obviously has an effect on who can be included. Online activities can mitigate or exacerbate inclusiveness. On the one hand, people who are less mobile or live in remote areas have better chances to participate, if they can participate online. On the other hand, if expensive hard- or software is required or a high-speed internet connection, this tends to exclude people with lower incomes and create a digital divide, especially in online citizen science.

It is remarkable that the focus on inclusion in science leans towards giving citizens the opportunity to do voluntary work, while many are excluded from studying at universities for merely financial reasons and remain widely excluded from a well-paid professional career in science. In a nutshell, inclusion is not an important aspect of a citizen science activity as long as the role of citizen scientists is similar to those of volunteers in charity work, who do not steer a project, and involving citizens, who are rarely involved in research, is not an important aspect of the research to be performed. However, their workload may be important here. Are they exploited as a cheap labour force (Mirowski, 2017)? Are paid jobs eliminated by the volunteer activities? Is there an appropriation of extensive knowledge of “non-scientific” experts, e.g., traditional ecological knowledge? (Walajahi, 2019)? And last but not least, what is the political, economic and cultural context of an activity? Does it strengthen non-egalitarian power structures? How may it impact on a community in which it takes place?

For obvious reasons, citizen science is not inclusive simply because non-specialists, sometimes imagined as being in need of science education, are invited to contribute to scientific projects. For instance, “participatory” agenda-setting in science or more time-consuming contributions can advantage even further those who are already cumulatively advantaged. On the other hand, as long as citizens have no more control over a project than volunteers in charity contexts, inclusion might not play such a crucial role. The example of citizen science shows that the requirements for democratic participation of citizens in scientific research and research-relevant decision-making processes are many times more complex than commonly assumed. Among other things, the question arises who is targeted. Probably citizen science advocates do not intend to provide a platform for anti-vaccination activists.

7 Overpromising

Notwithstanding the benefits and potential citizen science has for crowdsourcing, especially in biodiversity research, and science education, the claims that citizen science is inclusive per se, democratises science and enhances public understanding of science among those who participate in citizen science activities are too general and insufficiently substantiated to be taken at face value. Similar claims have been made about public engagement activities (Stilgoe et al., 2014), and there are similar debates in Responsible Research & Innovation (RRI), although more critical ones (e.g., see van Oudheusden, 2014, Bauer et al., 2021, van Mierlo et al., 2020). It would be worth a research project of its own to compare the promises of and the debates on inclusion in RRI, citizen science and public engagement in science.

Perhaps citizen science is another manifestation of the “participatory turn” (Jasanoff, 2003), the turn away from initiatives to promote public understanding of science that aimed at putting down public controversies on GMO and other controversial topics by informing publics policymakers imagined as uninformed and reacting only emotionally. Since about 2015 citizen science moves up on the totem pole of policymakers. It appears to be an answer to failing campaigns to promote public understanding of science and to the limitations of public engagement with sciences and the overpromising of those who pushed for it. However, we may witness a similar overpromising as in the case of former initiatives of public engagement in science here, which made quite similar claims in a similar manner (Stilgoe et al., 2014).

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References

Abels, G. (2009): Citizens ‘deliberations and the EU democratic deficit: Is there a model for participatory democracy? Tübinger Arbeitspapiere zur Integrationsforschung (TAIF) 1.

Arnstein, S. R. (1969): A ladder of citizen participation. In Journal of the American Institute of planners, 35(4), 216-224.

Auerbach, J., Barthelmess, E. L., Cavalier, D., Cooper, C. B., Fenyk, H., Haklay, M., & Shanley, L. (2019): The problem with delineating narrow criteria for citizen science. In Proceedings of the National Academy of Sciences, 116(31), 15336-15337.

Bauer, A. et al. (2021): Rethinking societal engagement under the heading of Responsible Research and Innovation: (novel) requirements and challenges. In Journal of Responsible Innovation 8(3). 342–363. https://doi.org/10.1080/23299460.2021.1909812.

Bonney, R. et al. (2009): Public participation in scientific research: Defining the field and assessing its potential for informal science education. A CAISE inquiry report. https://eric.ed.gov/?id=ED519688.

Burgess, H. K., DeBey, L. B., Froehlich, H. E., Schmidt, N., Theobald, E. J., Ettinger, A. K., HilleRisLambers, J., Tewksbury, J., & Parrish, J. K. (2017): The science of citizen science: Exploring barriers to use as a primary research tool. In Biological Conservation, 208, 113-120. https://doi.org/10.1016/j.biocon.2016.05.014.

Buytaert, W., et al. (2014): Citizen science in hydrology and water resources: opportunities for knowledge generation, ecosystem service management, and sustainable development. In Frontiers in Earth Science, 2: 26. DOI: https://doi.org/10.3389/feart.2014.00026

Citizen science. (n.d.-b): In Lexico.com. https://www.lexico.com/definition/ citizen_science.

Citizen science. (n.d.-c): In Oxford English Dictionary. https://www.oed.com, last access on March 11, 2021.

Cooper, C, et al. (2019): Project Categories to Guide Institutional Oversight of Responsible Conduct of Scientists Leading Citizen Science in the United States. In Citizen Science: Theory and Practice, 4(1): 7, pp. 1–9. https://doi.org/10.5334/cstp.202.

Council of Europe. (2022): About participatory democracy. Participatory Democracy. https://www.coe.int/en/web/participatory-democracy/about-participatory-democracy.

Dawson, E. (2018): Reimagining publics and (non) participation: Exploring exclusion from science communication through the experiences of low-income, minority ethnic groups. In Public Understanding of Science, 27(7), 772–786. https://doi.org/10.1177/0963662517750072

Eitzel, M. V. et al. (2017): Citizen Science Terminology Matters: Exploring Key Terms. In Citizen Science: Theory and Practice, 2(1), 1. https://doi.org/10.5334/cstp.96.

European Commission (2018): Horizon 2020: Work Programme 2018–2020: 16. Science with and for Society. https://ec.europa.eu/research/participants/data/ref/ h2020/wp/2018-2020/main/h2020-wp1820-swfs_en.pdf.

European Commission (2022): Citizen participation in Cohesion policy – an opportunity for Europe. https://ec.europa.eu/regional_policy/en/newsroom/panorama/2022/04/

27-04-2022-citizen-participation-in-cohesion-policy-an-opportunity-for-europe

Franzoni, C. & Sauermann, H. (2014): Crowd science: The organization of scientific research in open collaborative projects. In Research Policy 43:1 (2014), 1-20, https://doi.org/10.1016/j.respol.2013.07.005.

Fredheim, L. H. (2018): Endangerment-driven heritage volunteering: democratisation or 'Changeless Change'. In International Journal of Heritage Studies, 24:6, 619-633. DOI: 10.1080/13527258.2017.1399285.

Füchslin, T., Schäfer, M. S., & Metag, J. (2019): Who wants to be a citizen scientist? Identifying the potential of citizen science and target segments in Switzerland. In Public Understanding of Science. 2019;28(6):652-668. doi:10.1177/0963662519852020

Georgi, V. (2015): Integration, Diversity, Inklusion. In weiter bilden 2, 25-27. https://www.die-bonn.de/zeitschrift/22015/einwanderung-01.pdf

Gough, A. (2015): STEM policy and science education: scientistic curriculum and sociopolitical silences. In Cult Stud of Sci Educ 10, 445–458. https://doi.org/10.1007/s11422-014-9590-3.

Haklay M. (2013): Citizen Science and Volunteered Geographic Information: Overview and Typology of Participation. In Sui D. et al. (eds): Crowdsourcing Geographic Knowledge. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-4587-2_7.

Haklay, M. (2018, October 5): How many citizen scientists in the world? In Po Ve Sham – Muki Haklay's Personal Blog. https://povesham.wordpress.com/2018/10/05/how-many-citizen-scientists-in-the-world/.

Haklay, M. et al. (2021): What is Citizen Science? The Challenges of Definition. In Vohland, K. et al. (eds): The Science of Citizen Science (13 - 33). Springer.

Heigl, F., & Dörler, D. (2017): Public participation: Time for a definition of citizen science. In Nature 551: 168. https://doi.org/10.1038/d41586-017-05745-8.

Heigl, F., Kieslinger, B., Paul, K. T., & Dörler, D. (2019): Toward an international definition of citizen science. In Proceedings of the National Academy of Sciences 116(17). 8089-8092, April.

Irwin, A. (1995): Citizen Science: A Study of People, Expertise and Sustainable Development. Routledge.

Jasanoff, S. (2003): Technologies of Humility: Citizen Participation in Governing Science. In Minerva, 41(3), 223–244. https://doi.org/10.1023/a:1025557512320.

Jenkins, L. L. (2011): Using citizen science beyond teaching science content: a strategy for making science relevant to students' lives. In Cultural Studies of Science Education, 6(2), 501-508.

Kimura, A. & Kinchy, A. (2016): Citizen Science: Probing the Virtues and Contexts of Participatory Research. In Engaging Science, Technology, and Society 2. 331-361.

Kleijssen, L., van Boheemen, P., Appels, P., & van der Geest, E. (2017): D3.1 DITOs Web. https://cordis.europa.eu/project/id/709443/results.

van Mierlo, B. et al. (2020): Inclusion in responsible innovation: revisiting the desirability of opening up. In Journal of Responsible Innovation 7(3). 361–383. https://doi.org/10.1080/23299460.2020.1780409.

Mirowski, P. (2017): Against citizen science. It might style itself as a grassroots movement but citizen science is little more than a cheap land-grab by big business. https://aeon.co/essays/is-grassroots-citizen-science-a-front-for-big-business.

Nascimento, S. et al. (2018): Citizen science for policy formulation and implementation. In Citizen Science: Innovation in Open Science, Society and Policy (pp. 219–240). UCL Press. https://doi.org/10.14324/111.9781787352339.

van Oudheusden, M. (2014): Where are the politics in responsible innovation? European governance, technology assessments, and beyond. In Journal of Responsible Innovation 1(1). 67–86. https://dx.doi.org/10.1080/23299460.2014.882097.

Pandya, R., & Dibner, K. A. (eds.) (2018): Learning Through Citizen Science: Enhancing Opportunities by Design. National Academies Press. https://doi.org/10.17226/25183.

Pocock, M. J., Tweddle, J. C., Savage, J., Robinson, L. D., & Roy, H. E. (2017): The diversity and evolution of ecological and environmental citizen science. In PLoS One, 12(4), e0172579.

Ruiz-Mallén, I., Riboli-Sasco, L., Ribrault, C., Heras, M., Laguna, D., & Perié, L. (2016): Citizen science: toward transformative learning. In Science Communication, 38(4), 523-534.

Schrögel, P., & Kolleck, A. (2018): The Many Faces of Participation in Science. In Science & Technology Studies, 77–99. https://doi.org/10.23987/sts.59519.

See, L. (2016): Crowdsourcing, Citizen Science or Volunteered Geographic Information? The Current State of Crowdsourced Geographic Information. In ISPRS International Journal of Geo-Information, 5(5), 55. https://doi.org/10.3390/ijgi5050055.

Serrano Sanz, F., Holocher-Ertl, T., Kieslinger, B., Sanz Garcia, F. & Silva, C. G. (2014): White Paper on Citizen Science in Europe. http://www.zsi.at/object/project/ 2340/attach/White_Paper-Final-Print.pdf.

Shirk, J. L., et al. (2012): Public Participation in Scientific Research: a Framework for Deliberate Design. In Ecology and Society, 17(2). https://doi.org/10 .5751/es-04705-170229.

Stilgoe, J. et al. (2014): Why should we promote public engagement with science? In Public Understanding of Science, 23(1), 4–15. https://doi.org/10.1177/ 0963662513518154.

Strähle, M., & Urban, Ch., et al. (2021): Framework Conceptual Model D1.1. Zenodo. https://doi.org/10.5281/zenodo.5589618.

Strasser, B., & Haklay, M. (2018): Citizen Science: Expertise, Democracy, and Public Participation (No. 1/2018). Swiss Science Council. https://www.swir.ch/ images/stories/pdf/de/Policy_Analysis_SSC_1_2018_Citizen_Science_WEB.pd f.

Strasser, B. J. et al. (2019): “Citizen Science”? Rethinking Science and Public Participation. In Science & Technology Studies 32(2), 52–76. https://doi.org/10.23987/sts.60425.

Tancoigne, E. (2019): Invisible brokers: “citizen science” on Twitter. In JCOM 18(06), A05. https://doi.org/10.22323/2.18060205.

Urban, C., & Strähle, M. (2022): The Activities & Dimensions Grid of Citizen Science. In Proceedings of Science. https://pos.sissa.it/. (forthcoming).

Walajahi, H. (2019): Engaging the “Citizen” in Citizen Science: Who’s Actually Included? In The American Journal of Bioethics 19(8): 31-33.

Wiggins, A., & Crowston, K. (2011): From conservation to crowdsourcing: A typology of citizen science. In Proceedings of the 44th Annual Hawaii International Conference on System Sciences. https://doi.org/10.1109/HICSS.2011.207.

Wiggins, A., & Crowston, K. (2012): Goals and tasks: Two typologies of citizen science projects (pp. 3426–3435). In Proceedings of the 2012 45th Hawaii International Conference on System Sciences (HICSS), 3426–3435. IEEE, Maui. https://doi.org/10.1109/HICSS.2012.295.

Wiggins, A., & Crowston, K. (2015): Surveying the citizen science landscape. First Monday. https://doi.org/10.5210/fm.v20i1.5520.

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Can sustainability transition methodologies support urban governance? - Case study CDMX Tri-color Coalition

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Abstract. System change requires different perspectives to create synergies. Sustainability transitions is a field of research that intends to solve grand societal challenges with large-scale societal changes. Urban governance is related to the processes and relationships between the government and civil society delivered in towns and cities. This research aims to analyse in which degree can two sustainability transition methodologies support complex urban governance challenges. The case study was done as an exercise of the Tricolor Coalition for Mexico City's (CDMX) water and energy sectors. The two methodologies due to their its actionable and contextualizable application were: Doughnut Economics City Portrait Methodology to define "sustainability" for CDMX's water and energy context and the XCurve Framework to analyse the possible "transitions" processes required for a water and energy societal change. The results were that these methodologies were useful for governance in CDMX to create stronger networks between stakeholders with similar visions, and to exchange knowledge, resources, and ideas for change. However, it also found that applying these methodologies was insufficient to create governance change. The design of long-term, resourceful and accessible platforms is required to monitor and follow-up with the changes. More research is required to understand how to design and create these types of platforms.

1 Introduction

Urbanisation is set to increase in the coming decades together with global demographics (World Population Review, 2021). However, this trend entails complex challenges. To face them, multistakeholder urban governance is a recognized need to address these cities' complex contexts (Frantzeskaki et al., 2018). One way urban governance has been put into practice is through the creation of community arenas/ coalitions / urban labs of decision-makers that work together to collaborate toward a system change (Nevens et al., 2013; Raworth, 2021; Wittmayer et al., 2011).

These coalitions can serve as platforms to connect multiple and diverse stakeholders to implement systemic transformative action (Wittmayer et al., 2011), and build capacities (Frantzeskaki et al., 2018; Hölscher et al., 2019b). Systems thinking has been included as part of these platforms to increase the complexity knowledge of the stakeholders (Wittmayer et al., 2011). In comparison, the capacities have been acknowledged to be useful to support the ability of the stakeholders to develop and implement action to face the complexity they face(Frantzeskaki et al., 2018).

Coalitions around the world have been created to tackle global challenges such as sustainability or social inequalities. However, few of them have been put into practice in Global South urban contexts (Hölscher et al., 2019a). From these Coalitions, one that has been downscaled not only in the Global North has been the Doughnut Economic Coalitions (Raworth, 2021). They propose joint action towards a global socio-ecological transformation into a “safe and just space” based on Kate Raworth’s Doughnut Economics (2015). However, there are not yet Doughnut Economic Coalitions all around the world.

Mexico City (CDMX) is one of the fifth most populated cities around the world, with over 9 million inhabitants in its political boundary and 22 million in its urbanised area (INEGI, 2021; World Bank, 2020). It has water and energy (W&E) security challenges to guarantee the access of these resources to its growing population without compromising the environmental capacity of its resources.

The energy challenges include decreasing CO2 emissions (mainly caused by transport), energy consumption habits in the population, renewable energy development and funding, and energy poverty (Gobierno de la CDMX, 2019). The water challenges include unequal water distribution, floods, water pollution, missing infrastructure maintenance, professional capacity development, long-term transparency of information, dependency on water imports, lack of water infiltration, and coordination between different institutions at different levels (Gobierno de la CDMX, 2021; Mexico City’s Water System - SACMEX, 2020; Ministry of Natural Resources SEDEMA, 2019).

These challenges require multiple public-private and social stakeholders. However, there are few groups in the city that promote multi-stakeholder urban governance processes that can face these sustainability challenges.

The Tri-Color Coalition (Tricolor Coalition for Sustainability Transitions, 2022), as part of a group of agents in CDMX, decided to create a Doughnut Economic City Coalition using this idea for a coalition because of its adaptability for the local context in 2021. Furthermore, it aimed to support change in W&E governance challenges using sustainability transition methodologies. In this paper, we present and analyse the application of the Doughnut Economics City Portrait Methodology (City Portrait) and XCurve Toolkit (XCurve) sustainability transition methodologies in Mexico City’s Doughnut Economic coalition to support urban governance processes to respond to these W&E security challenges of the city.

2 Background

2.1 Systemic Change

The international challenges are complex and are in constant evolution. Thus, systems thinking perspectives have been used to comprehend these challenges' complexity (Voulvoulis et al., 2022). A system is "an interconnected set of elements that is coherently organised in a way that achieves something" (Wright and Meadows, 2008). Systems include: "elements, interconnections, and a function or purpose" (Wright and Meadows, 2008). Furthermore, there are different types of systems which have been analysed for sustainability (Loorbach et al., 2017): socio-technical, techno-economic, political, and socio-ecological. Each system has been created to analyse the sustainability complexity challenges that come with the links between societal actors and other elements they interact with.

2.2 Links between Sustainability Transitions and Urban Governance

Sustainability transitions and urban governance are fields where innovation looks for systemic change through local agents. They have different but complementary approaches to systemic change. Sustainability transition studies pathways and visions for systemic change (Loorbach et al., 2017; Markard et al., 2012). In comparison, urban governance provides information about the complexity of agents who promote these pathways (Abdel-Razek, 2021). Sustainability transitions could be a way where complex networks of governance agents find common pathways and visions for system change.

The link between sustainability and governance has been promoted in practice at an international level. The 2030 UN Agenda (the political treaty for sustainability transitions) recognizes the principle of common but differentiated responsibilities (principle based on a governance approach). This principle entails that states are the main agents responsible for guaranteeing basic needs and human rights, but the responsibility is shared between other agents (General Assembly, 2015). According to this principle, guaranteeing basic needs and human rights requires collaboration with non-governmental stakeholders. Even when this principle exists, one challenge is to include agents from different scales, sectors, and groups. This is required to create synergies and increase resources to tackle global problems. Sustainability transitions research proposes alternative methodologies to address this challenge, some of which are described below.

2.3 Sustainability Transitions Research

If collaborative work is required for sustainability transitions to promote governance processes, it is important to define the following two elements:

A collaborative definition of sustainability - which can serve as the normative framework for collaboration in governance

Collaborative Transition processes - an analysis of multiple possible transition pathways where collaboration can develop to promote governance

About Sustainability

From the Brundtland Report, sustainable development is the "development that guarantees the needs of the present without compromising the ability of the future generations to meet their own needs" (World Commission on Environment and Development, 1987). This definition highlights the focus of development of the current and future generation's needs. However, it does not explain nor clarifies which are these needs. A way in which sustainability transition research has proposed to formulate these needs has been by contextualising the needs to a particular place and time. For this, it has used systems thinking approaches to define the scope and parts of the system that is being analysed. From these systems, the socio-ecological system approach has been recognized to have a closer framework to sustainability (Fischer et al., 2015).

If the socio-ecological system is used as the framework for sustainability, we still require the normative elements of this framework contextualised to different times and places. Kate Raworth proposed a framework for an international normative perspective of a socio-ecological system called Doughnut Economics. In her framework, Raworth defines that the normative socio-ecological system our societies should work for is one that transits towards "a safe and just space" (Raworth, 2017).

She envisions a "just space" as the social and political values of the Sustainable Development Goals (SDGs) (Department of Economic and Social Affairs, n.d.; General Assembly, 2015). She describes the "safe space" as being within the limits of the science-based proposal of the Planetary Boundaries (Steffen et al., 2015). She has tested this approach at an international level, but has proposed further downscale analysis at national, regional and local level. (Raworth and Benyus, 2021). Sustainability, as envisioned by Raworth, means reaching the SDGs while respecting planetary boundaries. However, it does not include proposals for transitional pathways. Even when Raworth's definition gives a normative framework for sustainability, it misses the procedural requirements to achieve the proposed vision.

About Transitions

To respond to the procedural aspect of the transitions, several socio-technical frameworks have been created (Loorbach et al., 2017). From these approaches, one which has been developed into an actionable methodology is the XCurve (Hebinck et al., 2022; Loorbach et al., 2017). For this approach, transitions include two processes: innovation and disruption. These represent positive and negative feedback loops according to the principle of self-organisation of system's dynamics(Rambidi, 2014).

Doughnut Economics and the XCurve Framework have actionable guidelines for participatory action (Hebinck et al., 2022; Raworth and Benyus, 2021). Due to the usefulness of these methodologies to create transitional pathways for governance processes, as well as its actionable characteristics, they were applied in the context of CDMX by the Tri-Color Coalition during 2021 and 2022.

3 Aim and Research Questions

Aim and Research Questions

The aim of this paper is to analyse in which degree can the sustainability transition methodologies support complex urban governance challenges. Due to their socio-ecological relevance, the scope of the analysis is limited to the W&E sectors in CDMX. Moreover, the analysis of the activities was delimited to those done by the Tricolor Coalition, with its members and interested participants. Therefore, the audience for this paper are stakeholders interested in promoting governance processes and academia interested in the application of sustainability transformation methodologies.

The research questions that guide this research are the following:

RQ1: How to apply sustainability research methodologies in the Tri-Color Coalition to support CDMX's water and energy governance processes?

RQ2: To what extent are these methodologies adequate to support change in Mexico City's water and energy sector governance processes?

4 Methods

We (the Tri-Color Coalition) used an action-research approach. We followed the definition of action-research by Brydon-Miller et al., as "a participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human purposes, grounded in a participatory worldview which we believe is emerging at this historical moment. It seeks to bring together action and reflection, theory and practice, in participation with others" (Brydon-Miller et al., 2003). For this, we conducted five (5) participatory workshops in 2021 and 2022 and applied two methodologies: City-Portrait Methodology and the XCurve Framework. We triangled the information obtained from these workshops with the information done after a literature review of the water and energy challenges of Mexico City and interviews with relevant stakeholders. For the participatory workshops, we invited participants from the following groups procuring a balanced amount of participants per group: local government, enterprises, academia, NGOs, and citizens. All the participants were involved with W&E, because of their personal motivations, projects they are a part of or their main job.

4.1 Data Processing by Research Question

The data obtained in this year-long project comes from the events and interactions we had with our members and other stakeholders. Our dynamic objectives were methodically reviewed and iterated according to feedback and best practices from past events. Our timeline was the following:

Figure 1 – Action Research Timeline

Data Processing for RQ1 - How to apply sustainability research methodologies to support Mexico City's water and energy governance processes?

a) Data Collection - We used three methods: literature review, interviews and a stakeholder workshop. A literature review and interviews were done to understand the process of the creation of other Doughnut Coalitions around the world (Amsterdam, Berlin, Brazil, Barbados, California) as Tri-Color Coalition was based on these. Moreover, we developed a stakeholder workshop to collect data on their answers to this research question. We were involved and engaged first with CDMX's Doughnut Economics stakeholders and later with W&E decision-makers.

b) Data Reduction - To reduce the data, we made an inductive coding of the information collected from the literature reviews and the interviews and translated them into actionable working steps:

- Step 1 - Stakeholder Mapping
- Step 2 – Analysing the challenge
- Step 3 - Ideal Future Scenario
- Step 4 - Actionable project proposals.

c) Data Analysis - Finally, we made a literature review to find actionable sustainability transition methodologies we could use to address CDMX's W&E governance challenges.

Data Processing for RQ2 - To what extent these methodologies are adequate to support change in Mexico City's water and energy governance processes?

a) Data Collection: We collected data from the research for a stakeholder map from 4 codesign events with the members of the Tri-Color Coalition, an in depth literature review of W&E challenges in CDMX, indicators following the advice from experts, and a survey with the members of the Tri-Color Coalition and other agents of change. We obtained four types of data: a) challenges of CDMX's W&E challenges, b) stakeholders that could support the response to those challenges and, c) future scenarios of those stakeholders of what change would mean, d) possible actions where these stakeholders could jointly collaborate.

b) Data Reduction: As we collected a substantial amount of data, we summarised and condensed the data using two criteria: a) relevance for representative decision-makers and academic stakeholders, and b) valid data comparison.

c) Data Analysis: The data were analysed following the City-Portrait Methodology and the X-Curve Framework sustainability transition research methodologies. In each of the workshops and events, we allowed some space to iterate the analysis through codesign. Also, we did this iteration to ensure that the data translated accurately from our participants to our records. Furthermore, the results were reviewed with experts who are members of the Tricolor Coalition. The results of the survey were analysed statistically.

4.2 Actionable Sustainability Transition Methodologies

Sustainability transitions literature has been criticised for its small impact outside academia (Kirchherr, 2022). For the past decade, this criticism has motivated researchers to create manuals and guidelines to translate sustainability transitions academic knowledge into practical actions and make information accessible and context-sensitive (Raworth and Benyus, 2021; Silvestri et al., 2020; Wittmayer et al., 2011).

The reach of sustainability tools outside academia, high-income contexts (Doughnut Economic Coalitions in European cities, for example), and the third sector (such as Design Your Action in Southern Mexico) have been limited. Moreover, from our experience, the mentioned manuals and tools are not available in all the necessary languages, they often use difficult theoretical concepts which require advanced training from facilitators and participants. Also, they do not always needs or culture sensitive (Bartunek, 2007; Kaufman, 2022).

Moreover, from previous Coalition Founders' experiences learned from two (2) interviews and two (2) conferences, we learned that an individual methodology was insufficient to promote governance processes. Thus, based on this, we choose to follow two sustainability transition research methodologies in a complementary way.

4.2.1 About City Portrait and XCurve methodologies

City Portrait and XCurve have both theoretical explanations as well as actionable guidelines. City Portrait Methodology aims to address the analysis of the Doughnut Economics proposal in context, giving a vision for sustainability goals. In comparison, XCurve analyses of available interventions to reach said vision. In practice, we tested these two theories by adapting them to CDMX’s W&E governance process while finding a way, so they complement each other's actionable gaps.

City Portrait Methodology

The City Portrait Methodology serves as a workshop to analyse the sustainability ideal scenario of a group of stakeholders in a city. This methodology requires to choose the stakeholders that will participate in the workshop, the development of the workshop, and the analysis of the current state of the city and the stakeholders’ future vision of it (Raworth and Benyus, 2021).
Due to the priority of this research to support governance processes, we adapted of this approach by dividing this methodologies’ requirements into three (3) steps. The steps done to develop this methodology were the following:

- Step 1 – Stakeholder Mapping.

Using a Social Network Analysis, we made a stakeholder map (Yang et al., 2017). We identified and analysed CDMX’s agents of change in the W&E to create a network. The identification of diverse agents was based on research of social media, publications, and governmental videos using a snowball methodology. To ensure inclusive participation, we had continuous feedback from new agents during the process.

- Step 2 – Analysing the challenge using the Doughnut City Portrait questions
We facilitated four focus groups with experts and reviewed the literature to analyse the most relevant water-energy challenges in CDMX. The first two focus groups aimed to ask the participants about their needs as sustainability decisionmakers. These focus groups had balanced participation of between 20-40 agents from government, enterprises, academia, non-governmental stakeholders, and citizens. Two other focus groups were done with academic experts, one for water and one for energy, and they aimed to respond to four questions: 1) What are the social and environmental requirements in CDMX? 2) What is the scale of these requirements? 3) What indicators can be used to measure these requirements? 4) What are the ideal values of these requirements for CDMX?

The City Portrait Methodology consists of the analysis of a “safe and just space” in a geographical context. This method has been used at different scales and in different regions (Raworth, 2021). For inclusive purposes, it is done qualitatively, asking the four questions from Figure 2 below:

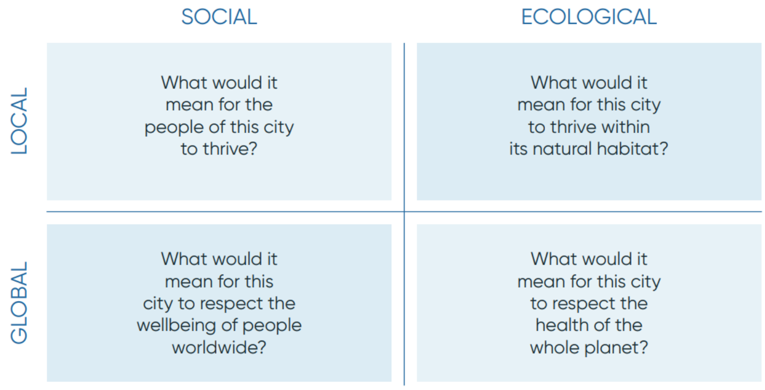

Figure 2 City Portrait Methodology canvas (Raworth and Benyus, 2021)

- Step 3 – Future Scenarios.

We created a survey based on Causal Layered Analysis for current and future scenarios of W&E in CDMX (Inayatullah, 1998). We aimed to identify how agents perceive the challenges today and what their expectations are for the future. We will use this material to create scenarios that can be used to define transitional paths. In the design of the survey, we aim to identify values, priorities, and expectations of agents of change in CDMX.

As used in design, future scenarios are useful tools to gather interests and values of the agents of change we are working with. Also, they spark creative thinking and promote action towards the co-created vision for the system.

XCurve Framework + Toolkit

The XCurve Framework, compared to other sustainability transition methodologies that analyse the dynamics of systems change, includes both the build-up and the breakdown patterns required for change. This framework resulted from a literature review and was then developed into an actionable framework paper (Hebinck et al., 2022) and a toolkit with different examples of workshops for its use(Giorgia Silvestri et al., 2022). The toolkit's main purpose is the analysis of the interventions in a context. Based on this toolkit, we applied this methodology in one step:

Analysis of CDMX water and energy projects

We made a focus group to analyse available interventions for sustainability transitions. We designed and facilitated a participatory online workshop adapting the guidelines proposed for this framework to our context and following the analysed results from our previous work. (Silvestri G., et. al, 2020). In this workshop, we invited the stakeholders who participated in the focus groups, and the ones who participated in the survey. We began the process by summarising the results of the previous research to the group. We presented the preliminary analysis of the challenges and some data from the survey to guide the conversation. In Figure 3, this image from the XCurve toolkit shows four moments that have to be asked during the workshops. Thus, during our focus group, we made four breakout rooms which rotated every 7 minutes, in a World Cafe Format.

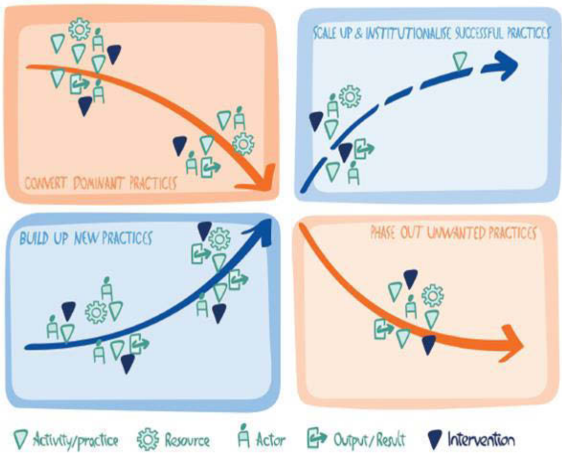

Figure 3 X-Curve framework Proposed Workshop Visualization (Silvestri, G, et. al, 2020)

We made some changes to the original guidelines of the XCurve Toolkit. To adapt this workshop to support governance processes, we extended the research from asking merely about which interventions the participants considered useful to inquire more about the feasibility of agents jointly implementing these interventions. For this, we asked three questions for each XCurve quadrant: 1) Which are concrete interventions for this quadrant? 2) Who can implement these interventions? 3) What are these agents' existent and missing capacities to implement these interventions? We did this adaptation after concluding that governance processes require understanding agency and capacities (Hölscher, 2019).

5 Results and Discussion

RQ1 - How to apply sustainability research methodologies to support CDMX's W&E governance processes?

We organised an initial event to co-create how to adapt sustainability research methodologies to CDMX's W&E sectors. From this event, we learned that stakeholders are interested in using these methodologies to support governance processes in the following ways(Tricolor Coalition and First Meeting Stakeholders, 2021):

- Develop communication tools.
- Create reference baselines.

- Create a support structure between the participants.
- Analyze the focus ideas and priority actions of the system.
- Create a platform to fund projects.
- Exchange knowledge.
- Compile existing research
- Evaluate existing development plans with the information obtained.

From these results, we decided to test methodologies that could help us to deliver the previous goals. Moreover, we realized the need of a platform where these services could be provided.

Following this initial event, the Tri-Color Coalition started then as a multistakeholder action-research project to find sustainability transitional pathways using Doughnut Economics and XCurve Framework. However, through the responses and requirements of the stakeholders for this action-research project, it showed the need to develop into a structured platform for collaboration due to the needs of the participants. The coalition at first had 3 members and, as of August 2022, there are 21 members and over 100 interested stakeholders. These members are individuals and institutions interested in sustainability coming from the government of CDMX, enterprises, NGOs, academia and citizens.

RQ2: To what extent are these methodologies adequate to support change in CDMX's W&E governance processes?

We analysed the degree to which these sustainability transition research methodologies were adequate to support CDMX's W&E governance processes. As a result, we obtained the following:

5.1 City Portrait Methodology

For the City Portrait Methodology, three steps were done: stakeholder mapping, identifying priority problems, analysing the future scenarios.

Stakeholder Map

For the stakeholder map 136, agents related to water, energy, and sustainability were identified in CDMX. There are agents from all three sectors, public, private and social, and academia. The agents identified were from the government, the private sector, the third sector, academia, and citizens. The stakeholders are part of either international, national, or urban levels. Agents involved in water (4 public projects and 1 private project) and energy (5 projects) were identified. In addition, another private project was chosen to understand the possibilities of collaboration within the private sector. From these stakeholders, 37 out of the 136 stakeholders were interested in being part of CDMX's Tri-Color Coalition (Fig 3, in black). As a result of the review of documents and audiovisual analysis, 14 experts from academia and the government sector were identified who played a key role in the implementation of W&E projects in CDMX.

Additionally, stakeholders that are implementing various energy or water projects in CDMX were identified within the stakeholder network analysis. Each of these stakeholders is characterised as node in Figure 4. In the graphic, the thickness of the lines that connecting one project with another depends on the amount of links we found between them. We call "multi-connectors" the nodes (circles) with more than one link. (Figure 4, orange = energy and navy blue = water). Likewise, stakeholders involved in both W&E projects were identified (Figure 4, green). In the following list, institutional names are shown for the super-connector of energy, water, or both:

The water multi-connector was CDMX's Water System Agency (Sistema de Aguas de la Ciudad de México). In comparison, there were several energy multi-connectors: a) Secretary of Energy, b) Federal Electricity Commission, c) Secretary of Economic Development of CDMX, d) Government of CDMX, e) National Polytechnic Institute, f) Trust for Energy Saving Electric, g) "Central de Abastos". Finally, from an energy-water nexus perspective, the energy-water multi-connectors were: a) Secretary of the Environment of CDMX, b) Secretary of Education, Science, Technology and Innovation, c) National Autonomous University of Mexico (UNAM), d) German Cooperation Agency for Sustainable Development (GIZ).

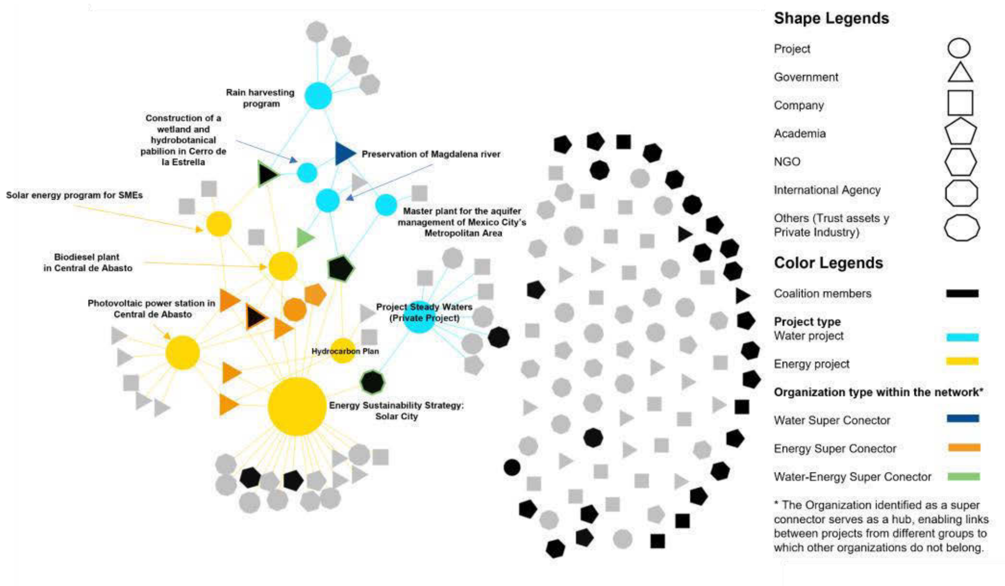

Figure 4 - Map of agents of change related to energy and water projects in CDMX. The geometric figures represent nodes (W&E projects in circles. stakeholders in other geometric figures). Meanwhile, the lines represent the interactions between nodes. This social network analysis is known as a "two-node network" since it connects the stakeholders with the projects that collaborated. Image credits: Ricardo Gomez Zamudio.

Finally, of the 136 stakeholders identified, 50 participated directly in W&E projects implemented in CDMX (Fig. 4 and 5). From these 50 stakeholders, 34% were part of the government, 20% companies, 14% international agencies, 12% academia, 10% NGOs, and 10% others (trust asset and private industry). From these results, we visualise the importance of collaboration between the business sector, government, academia, and international agencies for an effective governance implementation of W&E projects.

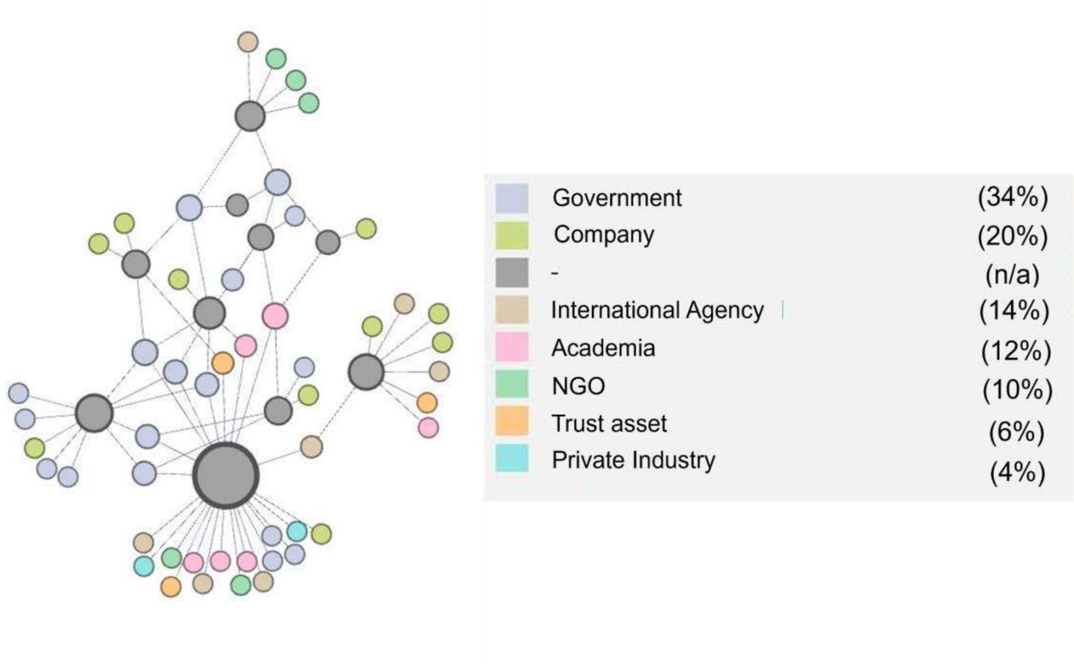

Fig. 5 Map of agents of change related to energy and water projects in CDMX divided by sector. Grey circles represent the analysed projects. Image credits: Ricardo Gómez Zamudio

Based on these results, we aim to show the governance agents of CDMX's W&E and their interconnections. The results show only a few agents serve as supper connectors in W&E. Moreover, the network is divided into branches, each directed by a multi-connector.

One possibility to support governance processes could be then to increase the quantity and quality of the multi-connectors relationships with other public-private-people partnerships. Also, it seems to be useful to support these multi-connectors to continue their collaborative work. Moreover, new agents could be supported as multi-connectors to increase the amount of local nodes and the resilience of the connections. It is worth mentioning that the GIZ collaborated on both public and private projects. Therefore, this analysis suggests that the work GIZ is doing could serve as a good practice example of what is required to strengthen public-private collaborations in CDMX.

We want to highlight that opportunities for improvement of actor network analysis exist as this map is not yet exhaustive of all the W/E relevant stakeholders in Mexico City.

A methodological update and a more extensive analysis of the Mexico City's stakeholders must be done. This analysis should include more extensive information about projects, agents of change, and levels of influence of the agents to be representative of the stakeholders in Mexico. Also, this map could include their levels of influence for the effective implementation of individual or joint projects in the future. Furthermore, participatory workshops with various agents of change in CDMX can be done, to enrich and expand the stakeholder map in the future.

Analysing the challenge

We facilitated two focus groups with academics specialised in W&E, which served to analyse the water and energy priority challenges in Mexico City. We included two experts from CDMX's water sector and three from the energy sector. From the water sector focus group, 45 topics were identified as priorities. These were found during research. From these, a coding exercise was done, and the following 13 priority topics resulted:

CDMX's Water Sustainability Priorities

1	Water reuse
2	Regeneration and conservation of ecosystems
3	Water consumption
4	Citizen and Community Participation in Hydrological Planning
5	Regulation
6	Hydrological Risks
7	Hydraulic Infrastructure
8	Monitoring
9	Urban expansion
10	Inter-scale coordination
11	Shared investment
12	Basic Needs
13	Territorial Planning

Table 1. Priority Topics for CDMX's water sustainability challenges according to a group of experts on the field. Source: Own Creation.

From the energy sector, 28 topics were identified. From these topics, a coding exercise was done and the following 11 priorities resulted:

CDMX's Energy Sustainability Priorities

1	Air Quality
2	Energy Reduction
3	Energy for those who need it
4	Political support
5	Innovation
6	Urban Planning
7	Renewable Energy
8	Energy Efficiency
9	Circular Economy
10	Social Acceptance
11	Subsidies

Table 2. Priority Topics for CDMX's energy sustainability challenges according to a group of experts on the field. Source: Own Creation.

From this data, we can see five relevant topics for both W&E: resource consumption, resource value chain, territorial planning, community and government engagement, and finance. In comparison, other topic priorities were different between W&E. For the energy sector, innovation and efficiency were considered a priority and, for the water sector, the regeneration of ecosystems and infrastructure.

The similar priorities that exist between the W&E sectors supports the existence of a water-energy nexus, as we have found in the literature (Ahuja,2015). This study is an initial discussion of the priority topics of W&E in CDMX and can be expanded in the future.

Future Scenarios

We have applied a survey (January - July 2022) to understand their values and priorities regarding sustainability transitions in CDMX. This survey is based on Causal Layered Analysis, a technique coined by Sohail (Inayatullah, 1998) and used foresight to define possible futures. We utilised the defined topics and indicators from the previous research (Stakeholder Mapping, p. 11) as starting points to create this survey.

This survey has been answered by 27 agents of change (People currently involved in water or energy projects in CDMX) within the Tri-Color Coalition. We have had a balanced response from different groups of the population, with the private sector (47.8%) being the most present, followed by academia (26.1%) and third sector (13%). We also had responses from residents of 8 different boroughs from the 16 in CDMX. Even though we have strived throughout this project to maintain gender representation, unlike the Tri-Color Coalition's participants, where 46% identify as male, a majority of the survey respondents identified as male (62.5%). These numbers in participation suggest that agents of change in CDMX are well distributed between different groups of the population, and the work of the Tri-Color Coalition has attracted balanced participation. Future efforts can be made to increase the participation of youth and the elderly, as well as lower-income groups and informal workers.

Although we will continue the analysis and share publicly detailed results and future scenarios from this survey, we are already identifying interesting patterns and pathways for future research within the preliminary analysis of the results. In addition, we obtained several qualitative responses to the W&E futures of CDMX that we will be analysing further:

According to the participants, the future for the water provision in CDMX appears to be very negative (59.2% of our respondents currently receive clean water daily (tap water), and 81.5% of the respondents fully agree with the statement "If current consumption continues, water in CDMX will be depleted". In contradiction, respondents believe their water consumption is sustainable (average 2.93 out of 5) and generally agree that their current consumption is enough for a dignified life (averaging 3.89 out of 5 (no-yes)). We gathered a substantial number of concrete suggestions for change ranging from improvement in water treatment facilities to changes in the subsidy policy for water in CDMX from participants. Water provision in CDMX is a top priority for the population and people. The results suggest that the outlook for water provision looks different between boroughs and incomes. In the future, the Tri-Color Coalition can focus on localised and specific water projects to provide context sensitive interventions.

On a different example from the energy sector, the future scenario, according to our respondents, is not as negative. Respondents are on average neutral towards current energy prices in CDMX (3 points (1 to 5) where in the question "energy is expensive in CDMX") with the clear exception of gasoline (gasoline has a strong division by sector; public sector respondents perceive gasoline as more expensive than the others (100% of public sector respondents answered they fully agree to "gasoline in CDMX is expensive" versus only 27% of all other sectors together). Respondents agree that consumption of electricity and gasoline will increase above inflation and believe energy will become more expensive. There is an important division in purchasing power by gender where people who identify as female struggle more to cover their daily energy costs (men answered on average 4.81 and women answered 4.45 to "I can afford my daily energy costs" (1=no, 5=yes). This suggests that sustainability transition pathways for energy will require intersectional interventions focused on differences between income and energy consumption by gender.

We can interpret the results of these surveys as interests and priorities on specific topics of agents of change. The exercise of finding interventions to achieve the desired futures are pathways for our common vision. These pathways allow us to identify and suggest, concrete points for intervention towards a more sustainable future for future research and projects. The scenarios that will result from the complete data analysis will provide us with a tool, based on social priorities, to advocate and communicate the need for sustainability transitions and their effect on people's quality of life; this is in line with the reflections from the first event.

5.3 Analysis of Current Projects Happening in CDMX

We adapted and applied XCurve Framework to analyse governance processes. We invited all engaging agents in the Tri-Color Coalition and made an open call for new participants. The participants included people from the government, the private sector, the third sector and international stakeholders. Due to privacy concerns, we will not publish the name of the stakeholders involved.

The results from this workshop are divided into two, disruptions and innovations, according to the XCurve Methodology. Moreover, each of these themes will be subdivided into three types of results:

- Interventions (required for a transformative change)
- Stakeholder roles (stakeholders that can implement these interventions)
- Capacities (existent and missing capacities of the stakeholders to implement these interventions).

5.4 Disruptive interventions

- Interventions:

The disruptive interventions that were stated in the workshop include: 1) over-consumption (and lack of sanctions to it), 2) inequality of resources, 3) pollution by citizens (as a normal citizen practice), 4) environmental degradation, 5) short-term vision (instead of long-term), 6) lack of trust in the system, 7) lack of investment in sustainable projects, 8) legal obstacles for production of renewable energy sources, 9) lack of monitoring of carbon emissions in energy production, 10) lack of an adequate value for energy and water, 11) lack of knowledge of the technical and economic feasibility of reducing CO2 emissions. The results show that the stakeholders chose which were the patterns and obstacles they saw were required for a sustainability transformation. These shows that governance processes for disruption require interdisciplinary efforts that come from political science, finance, education, economics and legal perspectives.

- Stakeholder Roles:

The agents recognized to be capable and responsible stakeholders for the interventions included public, private, NGOs and citizens. From the public sector, the federal and local level were recognized, and the executive and the legislative civil servants. From the private sector the list included: investors, industries and expert consultants. From the social sector three groups were mentioned: academia (including observatories), NGOs and city residents at a household level. These results showed that disruption mainly required agents with structural power.

- Capacities:

The participants described what actions agents of change could do to tackle the identified challenges: 1) legal defence, 2) lobbying in communities, 3) unity between stakeholders with same vision, 4) public writing manifestations, 5) social participation, 6) promotion of transparency, 7) registry of service providers, 8) circular economy and inclusive political will, 9) monitor/oversight by citizens.

The missing capacities mentioned were: 1) a fragmented society (they referred to "class" divisions), 2) political will, 3) citizen commitment, 4) dialogue between public and private stakeholders, 5) regulatory capacities in law and 6) enforcement of the law, 7) involvement of the affected agents, 8) communication about the transition, 9) decreasing bureaucracy obstacles, 10) involvement of different agents in the decision-making process and 11) transition of the staff into their new roles.

These results show political existent capacities. However, they show lack of communication, legal and cultural capacities.

5.5 Innovative interventions

- Interventions:

The participants stated innovative interventions through concrete projects that could be developed to reach the system's transformative goals. These included: 1) rain catchment, 2) water leakage analysis, 3) water crisis education, 4) enforcement of W&E payments, 5) advice for water basin councils, 6) incentives for renewable energy and water recycling, 7) strengthening the strategy of solar heating and water recycling in buildings, 8) increasing sustainability education, involving experts on the field, 9) citizens non-conformation with the problems 10) coherence between politicians and citizens actions, 11) taxes to negative externalities, 12) promotion of technological developments in W&E, 13)thermal efficiency regulation for building constructions, 14) economic incentives in taxes, 15) enterprise donations, 16) compilation of success practices for policy creation, 17) education Campaigns, 18) citizen council followup to interventions and 19) collaboration between government agencies.

- Stakeholder Roles:

We recognised four agents that can implement these interventions: 1) Public servants (different sectors, but not all of the government); 2) civil society (organised communities, citizen representatives and the citizens themselves), 3) developers for sustainability projects (private sustainability investors and small businesses for funding the sustainability projects and policy lobbying) and 4) academia (experts in sustainability and climate change from public and private institutions to spread the information of the current state and of new action proposals). They stated that their roles were divided, but that there was the need for collaboration amongst them.

- Capacities:

The capacities that we found through the workshop for these innovations included: 1) government reports 2) market prices for W&E and 3) long-term planning for governments (20 years).

The capacities the participants identified as missing included: 1) reception of projects, 2) Increased communication of expert institutions, 3) citizen or entrepreneurial counsel to monitor governmental action, 4) pressure from civil society, 5) legal modifications, 6) multi-stakeholder dialogue events, 7) understanding of the W&E agents, 8) reaching agreements between different stakeholders, 9) understanding of the current challenges, 10) information on how agents can support change, 11) taxation that show the real value of W&E, 12) creating a common vision, 13) creating a private funding commitment, 14) creating relevant legal sanctions, 15) increasing water measurements , 16) perfecting information and dissemination channels.

Figure 5 shows the results of the participatory workshop:

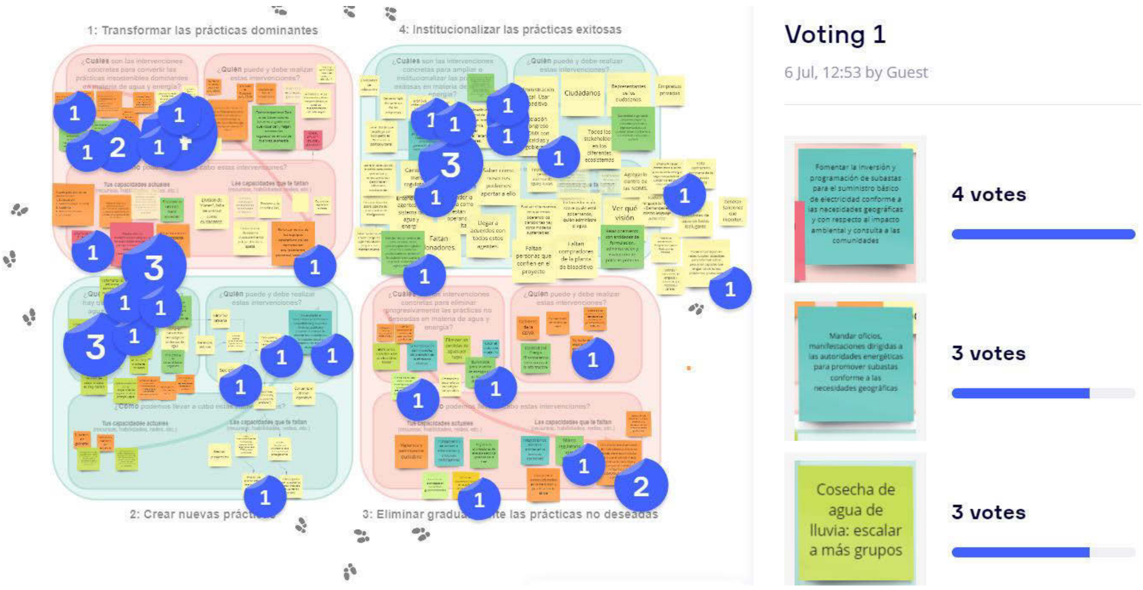

Figure 5 - Multi Stakeholder Intervention Analysis Workshop. Source: Own Creation Results from Intervention Analysis Workshop

In Figure 5, the quadrants in red show the disruptive interventions analysis and the ones in blue show the innovative interventions analysis. Moreover, on the right side of Figure 5, there is a list with the five interventions that had the highest number of votes from the participants. These were chosen as priority interventions for a sustainability transition in Mexico City taken into consideration feasibility and impact. These interventions show possible governance collaborations in the near future.

After finishing this workshop, the stakeholders finally answered a survey to understand the usefulness of this workshop. They stated that the most useful part of this workshop was the dialogue with other agents of change.

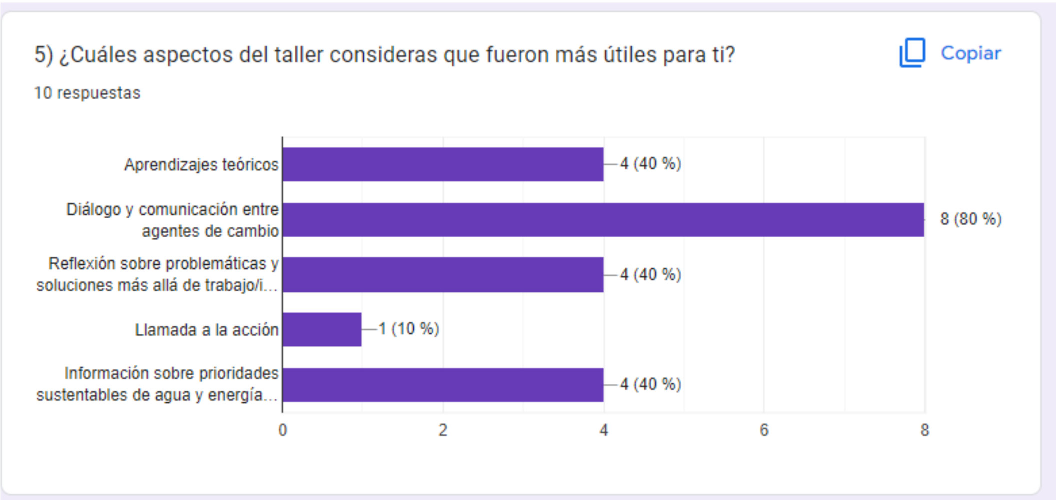

Figure 6 - Survey of the Intervention Analysis Workshop Source: Own Creation based on Survey.

Moreover, even when the participants of the workshop stated that the call to action was not as useful for them for this workshop, all of the participants said they would be open for future collaboration (20% of the participants answering "maybe" to these questions). This shows that there was a clear positive potential to continue developing governance processes.

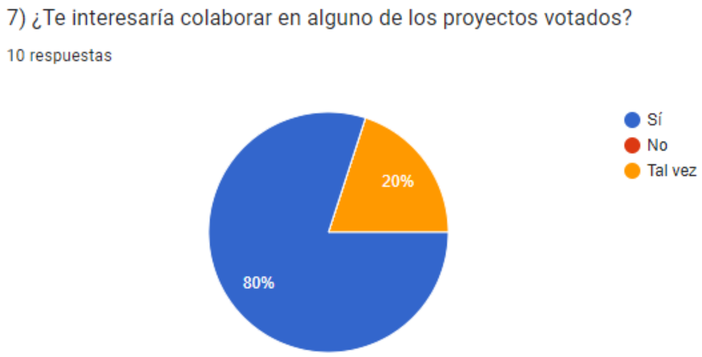

Figure 7 - Seventh Question in the Survey (Translation: 7) Would you be interested in collaborating on one of the voted projects? 10 answers: Yes, No, Maybe)
Source: Own Creation.

These results show how the adapted X-Curve toolkit served to analyse the interventions, roles, bottlenecks and opportunities for a sustainability transition CDMX's W&E sector. The workshop provided participants with a space for dialogue, holistic learning of the W&E priorities and a space to reflect and be informed on current issues and strategic opportunities. It also catalysed ideation of specific actions for sustainability transitions. Our results reflect the opinion of those who participated in the workshop and cannot be considered exhaustive. However, it does give an initial approach and guides us to future action research opportunities. Moreover, it shows that a longer-term project is required to not only analyse the governance vision of the stakeholders, but also to put it into action.

6 Conclusion

To respond to the first research question, and through a year of work with agents of change in the W&E sector in CDMX, we learned that the methodologies we decided to apply, with proper adaptations, are useful for creating a platform with multiple stakeholders. Continuous and long-term collaboration in various projects and events was useful as an action-research approach. We identified three ways in which these methodologies could be used to support governance processes: a) creating a network of agents of change, b) delivering updated and holistic information on the challenges and prioritise projects to address a sustainability transition in CDMX, and finally, c) supporting capacity building of agents of change at an individual and group level.

The importance given by stakeholders to networking must be highlighted. Agents of change were mostly interested in exchanging contacts, knowledge, ideas, and resources for reflection and action (Figure 6). With this research, we have acquired substantial data on CDMX agents of change in the W&E sectors. This data has opened opportunities for future projects and research.

Moreover, to respond to our second research question, we observed that these methodologies were adequate but insufficient on their own to support governance processes. These methodologies functioned better together, as neither provided all the elements we required to translate theory into action. Each of these methodologies made an analysis with a different perspective of the systemic challenges for a CDMX 's W&E sustainability transition: the vision of the change, the analysis of the current situation, the future vision of the stakeholders, and the possible interventions available. Each of these methodologies was insufficient for action. Still the complementation of these methodologies was useful to guide and co-create with stakeholders a complex system analysis reflection into possible collaborative action. These complementary methodologies used to support urban governance could also be applied to guide other sustainability transitions with a governance approach at an urban scale. However, they should also be adapted according to the stakeholders needs, for their involvement in the process and their benefit.

In addition, this research paper shows that sustainability transition methodologies are adequate to be applied to concrete cases in urban settings. They show that these systems thinking methodologies promote collaboration between governance actors and develop joint understandings and pathways for action. However, for them to be useful for governance processes, these methodologies must be co-contextualized and co-created according to the stakeholders that participate in them.

Moreover, we recognise that an action-research that brings people together cannot be done in the short term and requires both scientific basis but also social interaction, as they were two interests of the stakeholders when deciding to collaborate. Also, in the Tricolor Coalition, researchers and participants are volunteers interested in sustainability in CDMX. This shows the potential of the proposition. However, due to the scale of the problem, more extensive analysis are needed with more time and resources. Moreover, we saw a lack of participation of some stakeholders due to clarity and legitimacy of this platform. Thus, we believe a coalition building action-research to support governance processes requires an accessible long-term platform with resources, and legitimacy.

In this way, the action-research results can understand the common governance challenges and opportunities for sustainability transitions through time, and can help to facilitate the design and implementation of action between stakeholders. Finally, further research was also found to be required on the design of multi-stakeholder platforms to achieve dialogue between different agents and promote governance processes. The next objective for the Tri-Color Coalition will be to use the learnings for this design.

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References

Abdel-Razek, S.A., 2021. Governance and SDGs in smart cities context, in: Smart Cities and the Un SDGs. Elsevier, pp. 61–70. https://doi.org/10.1016/B978-0-323-85151-0.00005-1

Ahuja, S., 2015. Nexus of Food, Energy, and Water, in: Food, Energy, and Water. Elsevier, pp. 1–20. https://doi.org/10.1016/B978-0-12-800211-7.00001-6

Bartunek, J.M., 2007. Academic-Practitioner Collaboration Need not Require Joint or Relevant Research: Toward a Relational Scholarship of Integration. AMJ 50, 1323–1333. https://doi.org/10.5465/amj.2007.28165912

Brydon-Miller, M., Greenwood, D., Maguire, P., 2003. Why Action Research? Action Research 1, 9–28. https://doi.org/10.1177/14767503030011002

Department of Economic and Social Affairs, n.d. The 17 Goals. Sustainable Development.

Fischer, J., Gardner, T.A., Bennett, E.M., Balvanera, P., Biggs, R., Carpenter, S., Daw, T., Folke, C., Hill, R., Hughes, T.P., Luthe, T., Maass, M., Meacham, M., Norström, A.V., Peterson, G., Queiroz, C., Seppelt, R., Spierenburg, M., Tenhunen, J., 2015. Advancing sustainability through mainstreaming a social–ecological systems perspective. Current Opinion in Environmental Sustainability 14, 144–149. https://doi.org/10.1016/j.cosust.2015.06.002

Frantzeskaki, N., Hölscher, K., Bach, M., Avelino, F. (Eds.), 2018. Co--creating Sustainable Urban Futures: A Primer on Applying Transition Management in

Cities, Future City. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-319-69273-9

General Assembly, 2015. Transforming our world: the 2030 Agenda for Sustainable Development (Resolution No. A/RES/70/1). United Nations, Paris, France.

Giorgia Silvestri, Diercks, G., Matti, C., 2022. X Curve - A sense making tool to foster collective narratives on system change. DRIFT - EIT Climate-KIC Transitions Hub 26.

Hebinck, A., Diercks, G., von Wirth, T., Beers, P.J., Barsties, L., Buchel, S., Greer, R., van Steenbergen, F., Loorbach, D., 2022. An actionable understanding of societal transitions: the X-curve framework. Sustain Sci. https://doi.org/10.1007/s11625-021-01084-w

Hölscher, K., 2019. Transforming urban climate governance : Capacities for transformative climate governance.

Hölscher, K., Frantzeskaki, N., Loorbach, D., 2019a. Steering transformations under climate change: capacities for transformative climate governance and the case of Rotterdam, the Netherlands. Reg Environ Change 19, 791–805. https://doi.org/10.1007/s10113-018-1329-3

Hölscher, K., Frantzeskaki, N., McPhearson, T., Loorbach, D., 2019b. Capacities for urban transformations governance and the case of New York City. Cities 94, 186–199. https://doi.org/10.1016/j.cities.2019.05.037

Inayatullah, S., 1998. Causal Layered Analysis: Poststructuralism as Method. Futures 30, 815–829.

INEGI, 2021. Mexico City's Inhabitants. Instituto Nacional de Estadística y Geografía, Mexico, p. 6.

Kaufman, B.E., 2022. The academic-practitioner gap: Past time to bring in the practitioner perspective. Human Resource Management Review 32, 100895. https://doi.org/10.1016/j.hrmr.2022.100895

Kirchherr, J., 2022. Bullshit in the Sustainability and Transitions Literature: a Provocation. Circ.Econ.Sust. https://doi.org/10.1007/s43615-022-00175-9

Loorbach, D., Frantzeskaki, N., Avelino, F., 2017. Sustainability Transitions Research: Transforming Science and Practice for Societal Change 32.

Markard, J., Raven, R., Truffer, B., 2012. Sustainability transitions: An emerging field of research and its prospects. Research Policy 41, 955–967. https://doi.org/10.1016/j.respol.2012.02.013

Nevens, F., Frantzeskaki, N., Gorissen, L., Loorbach, D., 2013. Urban Transition Labs: co-creating transformative action for sustainable cities. Journal of Cleaner Production 50, 111–122. https://doi.org/10.1016/j.jclepro.2012.12.001

Rambidi, N.G., 2014. Self-Organisation: A Common Principle of Information Processing by Distributed Dynamic Systems, in: Rambidi, N.G. (Ed.), Molecular Computing: Origins and Promises. Springer, Vienna, pp. 167–184. https://doi.org/10.1007/978-3-211-99699-7_6

Raworth, K., 2021. Tools & Stories | DEAL [WWW Document]. Doughnut Economics Lab. URL https://doughnuteconomics.org/tools-and-stories?type%5B%5D=Methodology (accessed 7.28.21).

Raworth, K., Benyus, J., 2021. Creating City Portraits - Methodological Guide.

Silvestri, G., Wittmayer, J., de Geuss, T., 2020. Workbook for Urban Transition Makers. Horizon 2020 Framework Programme of the European Union.

Steffen, W., Richardson, K., Rockstrom, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B., Sorlin, S., 2015. Planetary boundaries: Guiding human development on a changing planet. Science 347, 1259855–1259855. https://doi.org/10.1126/science.1259855

Tri-color Coalition, First Meeting Stakeholders, 2021. First Meeting with Stakeholders.

Tricolor Coalition for Sustainability Transitions, 2022. About Us. Official Tricolor Coalition Webpage.

Voulvoulis, N., Giakoumis, T., Hunt, C., Kioupi, V., Petrou, N., Souliotis, I., Vaghela, C., binti Wan Rosely, Wih., 2022. Systems thinking as a paradigm shift for sustainability transformation. Global Environmental Change 75, 102544. https://doi.org/10.1016/j.gloenvcha.2022.102544

Wittmayer, J., van Steenbergen, F., Quist, J., Loorbach, D., Hoogland, C., 2011. Community Arena: Guidelines for the implementation of pilot projects.

World Bank, 2020. Population in largest city - World, Mexico. The World Bank Data.

World Commission on Environment and Development, 1987. Our Common Future - Brundtland Report: Report of the World Commission on Environment and Development.

World Population Review, 2021. World City Populations 2021. URL https://worldpopulationreview.com/world-cities

Wright, D., Meadows, D.H., 2008. Thinking in systems. Earthscan, London.

Self-Tracking: Ethical Considerations on Transparency and Privacy

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Abstract. This article reflects on self-tracking technologies as practices of individual transparency from an ethical point of view. As a conceptual contribution, it discusses transparency as a norm and democratic promise to the individual and presents an overview of ethical implications of a digitally transparent society and its tools. It discusses the notion of transparency as a powerful normative concept of 21st century digital societies. It goes on to argue that people become transparent on a digital level as practices such as self-tracking make individual transparency become an ideology of digital societies. Digital transparency is a concept directly opposed to that of privacy. From a liberal point of view, individual digital transparency and self-tracking pose a threat to self-determination, autonomy, and privacy, while at the same time promising autonomy. To understand these contradictory conceptual contexts, this paper explains the normative importance privacy holds for democracy and individual autonomy. In order to contain the resulting ethical ambivalences of self-tracking and transparency, this paper finally highlights the importance of special sensitivity and attention to differently distributed vulnerabilities, the need for democratic regulation, and for digital sovereignty in all age groups.

1 Introduction

The covid-19 pandemic has spotlighted the tension between data collection, data protection, and transparency, as debates about Covid apps, contact tracing, or data donations around Europe show (Sweeney, 2020; Simon and Rieder, 2021; Sharon, 2020). Transparency is a central buzzword in these debates, characterizing a prevalent ideology of digital societies (Watzinger, 2022). From a philosophical media ethics perspective, examining and understanding ambivalent concepts like that of transparency is a key goal, which is why this article focusses on the different dimensions of this concept and gives an overview of the ethical challenges connected to individual transparency. It is particularly interested in the transfer of the concept to the individual in the sense of data-induced transparency, which can be understood as an antipode to privacy (Watzinger, 2022; Weidacher, 2019). Individual digital transparency, however, implies a threat to informational self-determination (Lanzing, 2016). Common self-tracking practices show in an exemplary way the extent to which transparency as a concept applied to the individual stands in contrast to privacy. As privacy is a basis for developing self-determination and autonomy in a democratic society (Rössler, 2001), losing the former affects all citizens and challenges democratic society and its institutions. Nevertheless, not all digital media users may be equally affected by violations of their privacy as potential vulnerabilities are complex and differently distributed, which makes it necessary to adapt ethical considerations accordingly.

2 Transparency as a Keyword of Digital Societies

The term *transparency* seems to be a buzzword of 21st century political and democratic practice (Hood and Heald, 2006; Baumann, 2014) and a requirement in various contexts and disciplines. Transparency is a key concept for democracy theory, but with digital transformation it expands its meaning to include other aspects. Furthermore, it is a term with positive connotations that does not only describe, but also implies evaluation (Weidacher, 2019) – it is a highly normative concept. According to Weidacher (2019), digital societies in the 21st century are characterized by a digital media logic, which means the internet and its social use have shaped communication and human life. This digital transformation is marked both by datafication and the generating, transmitting, and publishing data, as well as by the neutralization of distance and delay that comes with disembodied communication. As a result, it is a common expectation to obtain (almost) any information anytime and anywhere and to be able to share it. Digital transformation fosters practices of transparency which in turn are to a large extent made possible by digital and networked technologies (Weidacher, 2019). Weidacher (2019) shows that as a result, transparency as an ideology forms part of such a digital media logic and digital society. So, as a political concept of 21st century digital societies it addresses not only the state and institutions, but also individuals (Alloa, 2018; Watzinger, 2022). This paper focuses on the transfer of the concept to the individual in the sense of data-induced transparency, which can be understood as the antipode of privacy.

3 Interdisciplinary Dimensions of a Concept

We have seen that transparency and the critical engagement with it are closely related to digital media, datafication, and their social effects. In this section, I show very briefly that transparency is a multidimensional, philosophically relevant concept on three levels: it is normative, it is metaphoric, and it refers to the state as well as to the individual. The normativity of *transparency* becomes evident through its ideological character, the details of which I discussed above. As a ‘magical concept’ which stands for enlightenment and openness, it points far beyond an institutional context (Alloa, 2018). This multidimensionality and metaphorical aspect of the concept becomes clearer when we take a look at transparency’s role in art and architecture theory (Rowe and Slutzky, 1963; Barnstone, 2003). In architecture, transparency is closely connected to glass as a material that claims to epitomize accessibility and democracy (Barnstone, 2005). In this sense, transparency can be understood as a metaphor of modernity. As such, it has been experiencing great popularity for decades and especially in the 21st century (Alloa, 2016). In a nutshell, the term *transparency* evolves as a material concept in glass architecture, is used as a metaphor for democracy and modernity, and ends up as a concept of the individual (Watzinger, 2022; Weidacher, 2019; Lanzing, 2016).

4 Privacy, Transparency, and Democracy – a Liberal Approach

In the context of digital transformation, societies face individual transparency and an increasing loss of information control which consequently poses obstacles to privacy (Hagendorff, 2017). Individual privacy and transparency, in this context, may be understood as opposing concepts (Watzinger, 2022). Both concepts are equally important for democracy theory: transparency traditionally is a follow-up concept for publicity, which transfers its meaning to apply to the individual – a published individual, so to speak. In contrast, privacy, from a classical liberal philosophy point of view, can be understood as something that opposes publicity and transparency. Rössler (2001; 2017) shows the normative and conceptual links that privacy has with autonomy and individual self-determination. Following her liberal approach, privacy is not a natural sphere, but a result of social norms and negotiation processes. In Rössler's understanding, a sphere is private if a person is able to control access to it. *Sphere* in this context should be conceptualized in a general and figurative sense (Rössler, 2001, p. 23f.). The protection of one's privacy thus means protection against unwanted access by others (Rössler, 2001, p. 23). The philosopher Rössler distinguishes three dimensions of privacy. On a decisional level, a person, in order to form their own opinion and develop their personality, has to be free from interferences regarding their actions as well as their decisions. Here, first, *access* refers metaphorically to the emotional access to a person, that is, whether someone is able to influence another person's convictions, behaviour, and decisions. Second, on a local dimension, *access* refers to who can enter another person's private space, such as their home. Third, also in a figurative sense, *access* has an informational dimension and refers to what someone knows about another person. According to this liberal theoretical conceptualization of privacy as Rössler develops it, dimensions, actions, situations, spaces, or even mental states can be private. If we define privacy like this, it is essential for people to be “let alone” (as Warren and Brandeis (1890) have phrased it), i.e. to be shielded from unwanted access of others to freely develop their personality, to make their own decisions, and to be themselves (Rössler, 2001). In a nutshell, being free of observation and access by others is, from this perspective, the only way to realize individual autonomy, which is the basis of democratic self-determination (Rössler, 2001). Only an intact and protected private sphere allows people to be autonomous, to act freely, to develop their own opinions and self-image, and consequently to participate in a democratic community. The philosophical connection of individual self-determination as a foundation of democratic participation shows the individual as well as the social relevance of privacy. Therefore, the social dimensions and values of privacy should be philosophically emphasized (Rössler and Mokrosinska, 2015) because what is considered private always has social significance. The protection of privacy thus enables the creation of communicative spaces where social contacts can be maintained and opinions can be uttered and reflected, practices which are elementary for the realization of democratic ways of life (Seubert, 2017, p. 126). These underlying theoretical concepts make digital privacy and privacy-invasive digital technologies socially and politically relevant.

5 Individual Transparency through Self-Tracking

Digitally connected, mobile self-tracking-devices like smartphones or wearables are popular as well as ubiquitous and offer a variety of tools for monitoring personal data, behaviour or even mental states. They can help a person to feel better, but may as well cause privacy or wellbeing risks (Herzog and Kellmeyer and Wild, 2021; Lanzing, 2016). To better understand the phenomenon of self-tracking practices, it is important to take a look at the motivation and mechanisms of individual data collection via self-tracking tools, its uses and benefits as well as possible risks. In the end, positive and negative aspects must be weighed against each other. Self-tracking is of major ethical interest (Herzog and Kellmeyer and Wild, 2021, p. 9) because it raises questions of individual transparency and privacy, self-knowledge, self-consciousness, and self-determination. Self-tracking practices, when understood as practices of transparency, are ethically relevant since they affect traditional philosophical concepts of individual freedom, autonomy, and overall, the question of a happy life (Rössler, 2020). Voluntarily used self-tracking technologies individualize transparency. From a philosophical and ethical perspective, the previously described conceptual shift of transparency into an individual norm shows to be a major challenge. Self-tracking can help to improve fitness and health and it can be fun. One motivation may be a desire for datafied self-knowledge based on numbers, as such technologies are supposed to increase information about one's own body or habits (Lanzing, 2016). Another related aspect is self-optimization via increasing a person's efficiency, health, or fitness (Duttweiler and Passoth, 2016). In order to be part of a digital community and to compare with other users, data on physical activity, behaviour, habits, even moods, is tracked and shared with other users via social media. There are apps for lifestyle self-tracking as well as apps that explicitly monitor diseases. Although the latter are (still) used rather rarely (Seifert and Meidert, 2018), it is a growing field and the range of users who use digital data collection to support the treatment of specific diseases is increasing (Sharon, 2017; Steinert, 2017). Furthermore, elderly people have become an important user group for medical purposes (Caldeira, 2020; Seifert and Meidert, 2018). However, constant comparison, surveillance, and control may also cause mental illnesses, such as depression or addiction (Hussain et al., 2015; Kreitmayr and Cho and Magnus, 2017); having one's attention constantly focussed on such tools, too (Herzog and Kellmeyer and Wild, 2021, p. 12). This makes further critical reflection on such ubiquitous technologies and practices vital.

6 A Privacy Approach to Self-Tracking

As self-tracking apps need large amounts and permanent flows of data (Herzog and Kellmeyer and Wild, 2021), they bear inherent risks of losing control over their collected data and information. Accordingly, self-tracking as a transparency practice challenges informational as well as decisional privacy, both of which are essential for individual autonomy, as I showed earlier (Lanzing 2016; 2019; Rössler 2017). From a media ethics perspective, however, it has to be kept in mind that self-tracking as a lifestyle is a voluntary and deliberate practice. For an ethical evaluation, the fact that its use is voluntary is crucial, as it creates a tension between individual transparency, the surveillance potential of self-tracking, and the voluntariness of such self-disclosure and privacy losses. From a philosophical perspective, the motivation behind self-tracking may be understood as a modern, digital promise of happiness corresponding with a digital media logic and potentially leading to individual quantification and commodification (Rössler, 2020). One ethical question of concern then is, if users know what they are doing and understand potential privacy consequences, which makes digital literacy one of the most important needs of digital societies. Self-tracking can be characterized by datafication, networking, and publication, but also by permanent surveillance (Maschewski and Nosthoff, 2021) as the other side of the coin. This means that digital self-tracking differs from 'classical' analogue recordings such as diaries, as Lanzing (2016) emphasizes, as they record automatically and constantly in order to further process the results and share them with a community, whereas diary writing generally aims for a personal self-reflection process (Lanzing, 2016, p. 11). Locating one's own data in digital communities is central for digital self-tracking; the individual receives feedback as well as evaluation (by others or an AI). Combined with its networking character, self-tracking relies on mechanisms of observation and surveillance – although done voluntarily – and owns the potential to objectify and commodify persons, as their data become mere tradable goods (Rössler 2017; 2020). Consequently, from a privacy perspective, data collection and (even voluntary) digital self-exposure prove highly problematic (Lanzing 2016, p. 10). There is obviously a conceptual tension between the idea that disclosing personal information through self-tracking increases one's autonomy and the idea that informational privacy is a condition for precisely this autonomy, as Lanzing (2016; 2019) points out. Besides its lifestyle use discussed above, self-tracking is also gaining relevance for serious medical and health purposes (Sharon, 2017), although the difference between hedonistic fitness tracking and medical tracking may not always be clear (Meidert et al., 2018), as it is possible to assume a user's health situation based on their fitness data, and fitness is strongly connected to health. Moreover, social conceptions of health or therapy have constantly been changing. As prevention is gaining more and more importance, making use of such digital health tools can be considered sensible.

7 Vulnerabilities and Self-Tracking

As I have shown above, self-tracking practices are a reality of digital societies and have become part of everyday life. These tools are ethically interesting because different ethical values come into conflict. On the one hand, individuals become digitally transparent through their data, as self-tracking practices are practices of individual transparency, which I have already pointed out; on the other hand, most people use these apps voluntarily. From an ethical perspective, self-tracking is a contradiction in itself: it promises to increase individual self-determination through individual, datafied transparency, but at the same time, such transparency is at odds with the privacy necessary for an autonomous life, as liberal theories propose. An ethics approach attempts to identify benefits, risks, and vulnerabilities. *Vulnerability* has become an important concept in bioethics and in public health management to evaluate and identify health risks (Herzog and Kellmeyer and Wild, 2021, p.12). From a more general philosophical perspective, we as humans are per se vulnerable, but not everyone to the same extent. Herzog et al. (2021) define such persons as vulnerable "who are not in a position to make their own decisions freely (such as prisoners), and who cannot formulate them adequately (such as people with severe dementia)" (p. 13). As they point out, people can be particularly vulnerable due to their situation in life or the context they are in. Vulnerabilities can therefore be dynamic, situational, or relational, i.e., they are not caused by the vulnerable person, but by their circumstances. This focus on the circumstances of life shows the political and social dimension of vulnerabilities (Herzog and Kellmeyer and Wild, 2021, p. 14). What vulnerabilities arise in the case of self-tracking and digital transparency? As I have shown above, digital transparency can go hand in hand with a threat to and loss of privacy that make individuals digitally vulnerable. One important and growing digital user group generally considered vulnerable are seniors (Reidl et al. 2020; Caldeira, 2020) since they bear – on a physical level – a greater risk of illness, as they may suffer chronic diseases and health restrictions more often. Nevertheless, the elderly should not simply be categorized as vulnerable (Bozzaro and Boldt and Schweda, 2018), but recognized as a complex and dynamic social group. For the elderly in particular, self-tracking can hold special potential as the options for its use are numerous and diverse. Tracking tools for seniors are thus a growing field (Vargemidis et al., 2020). Even among senior users, the applications of self-tracking as a lifestyle prevail, but medical use is gaining importance (Seifert and Meidert, 2018, p. 356f.; Vargemidis et al., 2020). Users monitoring specific diseases and health risks, e.g., cannot simply decide to stop using an app, which may make them more dependent on it. For elderly users, explicitly health-related aspects of self-monitoring and preventive health care seem to be particularly important, whereas the connection to a digital community appears to play a minor role (Seifert and Meidert, 2018, p. 256). The informational dimension of seniors' possibly increased vulnerability refers to the higher sensitiveness of personal health and illness data in comparison to common and voluntary fitness data. Furthermore, the digital and media competences are central and may determine, i.e., if an (elderly) person is capable of deciding whether they should use tracking or not. Thus, one mechanism to reduce concrete vulnerabilities with regard to digital media and its threats to privacy is focusing on informed consent (Herzog and Kellmeyer and Wild, 2021) for all users. Informed consent means ensuring users' digital literacy and sovereignty in all age groups and life situations. In conclusion, the discussed potentials of self-tracking for health and age monitoring should be considered with regard to their ambivalences for differently vulnerable user groups for whom medical use and privacy issues may conflict. The special vulnerability of senior users just shows in a highlighted way the tensions between privacy, digital sovereignty, and transparency. The use of data-processing technologies in the field of self-tracking and medical applications is always associated with risks regarding the protection of extremely sensitive data and thus the privacy of the users. The more vulnerable persons are, and the less capable of protecting or defending themselves against potential risks, the more sensitive their data is.

8 Ethical Conclusion

The supposed promise of self-control and empowerment through self-tracking makes it easy for us to lose sight of the fact that the large amounts of data produced in the process, once they exist, are processed, may be revealed to others, and in consequence may limit users' possibilities of acting independently of others. The mere existence of such enormous flows of data may create potentials of control (Schaupp, 2016). Thus, data protection is an extremely sensitive issue in the use of self-tracking applications – this holds true for all users, but even more so for vulnerable groups. It is a political and societal task to regulate data processing and protection in order to enjoy the potential and benefits of digital applications while minimizing their risks (Herzog and Kellmeyer and Wild, 2021). Overall, from a media ethics perspective, it can be stated that users should be able to control the disclosure of information and retain control over their data on a technical as well as a level of digital literacy no matter their age or life situation. Nevertheless, it is a personal decision of each and every individual whether to engage in self-tracking or not. This voluntariness is very important for an ethical point of view. The possible benefits provided by self-tracking should therefore be evaluated by individually weighing up personal benefits, risks, and vulnerabilities. Self-tracking applications also have a clear social as well as political dimension and relevant effects on different user groups (Reidl et al., 2020). In this context, some individuals turn out to be more vulnerable than others. The potentials and risks must therefore be politically regulated to avoid perpetuating or reinforcing existing vulnerabilities and inequalities or even creating new ones. The fundamental threat to and dissolution of privacy affects all users, but some even more than others. For this reason, it is important to keep in mind these special needs for the designing of apps as well as for business models and political regulation, and to take the living and communication situation of all persons into account (Herzog and Kellmeyer and Wild, 2021; Reidl et al., 2020). Approaches that lead to privacy by design could be pushed and promoted on a political level to enable users to ensure their data protection. Furthermore, users of all ages and life circumstances should be digitally sovereign to trade potentials and perils and they need to be able to rely on regulated, safe infrastructures (Sharon, 2021). This requires not only secure data protection, but also the digital competence of the users. A critical approach and broad digital competencies are needed to realize individual digital sovereignty regardless of age and circumstances.

References

Alloa, E. (2018): Transparency: A Magic Concept of Modernity. In: E. Alloa; D. Thomä (eds.): Transparency, Society and Subjectivity. Critical Perspectives, pp. 21-55.

Alloa, E. (2016): Was kommt, steht im Zeichen der Transparenz. Über Glasarchitektur und das ambivalente Erbe des Modernismus. In: T. Thiel; S. Neuenschwander (eds): Transparenzen/Transparencies. The Ambivalence of a New Visibility, pp. 62-69.

Barnstone, D. A. (2005): The transparent state. Architecture and politics in postwar Germany.

Barnstone, D. A. (2003): Transparency: A Brief Introduction. In: Journal of Architectural Education 56 (4), pp. 2-5.

Baumann, M. (2014): Die schöne Transparenz-Norm und das Biest des Politischen: Paradoxe Folgen einer neuen Ideologie der Öffentlichkeit. In: Leviathan 42 (3) 2014, pp. 398-419.

Bozzaro, C; Boldt, J., Schweda, M. (2018): Are older people a vulnerable group? Philosophical and bioethical perspectives on ageing and vulnerability. In: Bioethics. Special Issue: The Ethics of Ageing 32 (4), pp. 233-239.

Caldeira, C. (2020). Self-tracking technology for senior health: existing practices and unmet needs for wellness, self-management, and recovery. UC Irvine. https://escholarship.org/uc/item/8w7621ks.

Duttweiler, S.; Passoth, J.-H. (2016): Self-Tracking als Optimierungsprojekt? In: J. Strübing et al. (eds.): Leben nach Zahlen. Self-Tracking als Optimierungsprojekt? Bielefeld, pp. 9-44.

Hagendorff, T. (2017): Das Ende der Informationskontrolle. Digitale Mediennutzung jenseits von Privatheit und Datenschutz.

Herzog, L.; Kellmeyer, P.; Wild, V. (2021): Digital behavioral technology, vulnerability and justice: towards an integrated approach. In: Review of Social Economy 80 (1), pp. 7-28.

Hood, C.; Heald, D. (eds.) (2006): Transparency. The key to better governance? Oxford.

Hussain, M., Al-Haiqi, A., Zaidan, A. A., Zaidan, B. B., Kiah, M. L. M., Anuar, N. B., Abdulnabi, M. (2015). The landscape of research on smartphone medical apps: Coherent taxnomy, motivations, open challenges and recommendations. In: Computer Methods and Programs in Biomedicine, Vol 122 (3), pp. 393–408. https://doi.org/10.1016/j.cmpb.2015.08.015.

Kreitmair, K.; Cho, M.; Magnus, D. (2017). Wearable and mobile health technology: Consent and engagement, security, and authentic living. In: Nature Biotechnology, 35 (7), pp. 617–620. https://doi.org/10.1038/nbt.3887.

Lanzing, M. (2019): “Strongly Recommended” Revisiting Decisional Privacy to Judge Hypernudging in Self-Tracking Technologies. In: Philosophy&Technology 32, pp. 549–568. https://doi.org/10.1007/s13347-018-0316-4.

Lanzing, M. (2016): The transparent self. In: Ethics and Information Technology 18 (1) pp. 9-16.

Maschewski, F.; Nosthoff, A. V. (2021): Überwachungskapitalistische Biopolitik: Big Tech und die Regierung der Körper. In: Z Politikwiss 2022 (32), pp. 429-455. https://doi.org/10.1007/s41358-021-00309-9

Meidert U.; Scheermesser, M.; Prieur Y. et al. (2018): Quantified Self – Schnittstelle zwischen Lifestyle und Medizin. https://digitalcollection.zhaw.ch/bitstream/11475/4977/1/3892_Quantified-Self_OA.pdf.

Reidl, S.; Streicher, J.; Hock, M.; Hausner, G.; Waibel, F.; Gürtl, F. (2020): Digitale Ungleichheit. Wie sie entsteht, was sie bewirkt ... und was dagegen hilft. https://www.ffg.at/laura-bassi-4.0-digitalisierung-und-chancengerechtigkeit

Rössler, B. (2020): Fashioning Our Selves? On Understandig and Criticizing the Digitized Society. In: Christ, J. et al. (eds.): Debating critical theory. Engagements with Axel Honneth, pp. 205-223.

Rössler, B. (2017): Autonomie. Ein Versuch über das gelungene Leben.

Rössler, B.; Mokrosinska, D. (eds.) (2015): Social Dimensions of Privacy.

Rössler, B. (2001): Der Wert des Privaten.

Rowe, C.; Slutzky, R. (1963): Transparency: Literal and Phenomenal. In: Perspecta 8, pp. 45–54.

Schaupp, S. (2016): "Wir nennen es flexible Selbstkontrolle." Self-Tracking als Selbsttechnologie des kybernetischen Kapitalismus. In: J. Strübing et al. (eds.): Leben nach Zahlen. Self-Tracking als Optimierungsprojekt? Bielefeld, pp. 63-86.

Seifert, A.; Meidert, U. (2018): Quantified seniors. Technisch unterstützte Selbstvermessung bei älteren Personen. In: Prävention und Gesundheitsförderung 13 (4), pp. 353-360.

Seubert, S. (2017): Das Vermessen kommunikativer Räume. Politische Dimensionen des Privaten und ihre Gefährdungen. In: Forschungsjournal Soziale Bewegungen 30 (2), pp. 124-133.

Sharon, T. (2020): Blind-sided by privacy? Digital contact tracing, the Apple/Google API and big tech's newfound role as global health policy makers. In: Ethics and Information Technology 2021 (23), pp. 45-57.

Sharon, T. (2017): Self-Tracking for Health and the Quantified Self: Re-Articulating Autonomy, Solidarity, and Authenticity in an Age of Personalized Healthcare. Philosophy&Technology 30, pp. 93–121. https://doi.org/10.1007/s13347-016-0215-5.

Simon, J.; Rieder, G. (2021): Trusting the Corona-Warn-App? Contemplations on trust and trustworthiness at the intersection of technology, politics and public debate, In: European Journal of Communication 36 (4), pp. 334-348.

Steinert, A. (2017): Selbstmonitoring als Instrument zur Verbesserung des Gesundheitsverhaltens älterer Menschen. https://refubium.fu-berlin.de/bitstream/handle/fub188/8561/Diss_ASteinert.pdf?%20sequence=1.

Sweeney, Y. (2002): Tracking the debate on COVID-19 surveillance tools. Nature Machine Intelligence 2, pp. 301–304 (2020). https://doi.org/10.1038/s42256-020-0194-1.

Vargemidis, D.; Gerling, K.; Spiel, K.; Vanden Abeele, V.; Geurts, L. (2020): Wearable Physical Activity Tracking Systems for Older Adults — A Systematic Review. In: ACM Trans. Comput. Healthcare 1 (4), pp. 1-37. https://doi.org/10.1145/3402523

Warren, S.; Brandeis, L. (1890): The Right to Privacy. In: Harvard Law Review, 4 (5), pp. 193-220

Watzinger, L. (2022): Transparenz. Herausforderung für Demokratie und Privatheit.

Weidacher, G. (2019): Die Ideologie der Transparenz. Werte- und Bewertungskonflikte im Diskurs über Transparenz, gläserne Menschen und Überwachung vor dem Hintergrund internet-geprägter Lebensformen. In: Steen, P.; Liedtke, F. (eds.): Diskurs der Daten, pp. 97-122.