



Framing Commons for Society-Technology for Electric Infrastructure Supply Systems

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This work discusses the dosage of technological systems for infrastructure arrangements and how the concept of commons-based prosumption could be integrated into energy systems and associated transition processes and agency from the bottom up. We span up conceptual tensions across the range of individual and collective interests, namely along the lines of sovereignty and solidarity. To highlight caveats for the use of technologies across different subsections of human societies we suggest ecosystem theory as an extension to other frameworks. We apply those insights to a framing of commons at the interface between technology and society for the socio-technical system of distributed electric energy provisioning. The energy co-prosumer, a fictive character, who would be an agent to help build the common pool resources logic for society-technology is presented. We show that technology as a tool can enable and assist to achieve transformational change and introduce the commons-based co-prosumer instead of the individual-based prosumer. These concepts help discern role, rule and control systems for operational as well as system design aspects of sustainable energy

transitions and how these can fit together to mould transformational changes from a systems perspective.

Keywords: energy co-prosumer, governance, control systems, self-determination, socio-technical system.

1 Introduction

Sustainability transitions aim to (re-)design structures and possible pathways towards scenarios that are more inclusive socially and more responsible with respect to surrounding ecosystems. Environmental and human systems are to co-exist in balance both from local and global perspectives as well as over time considering future generations. The aim should be towards more sustainable and resilient systems and one pathway to achieve them could incorporate addressing challenges by sharing responsibilities given the increased number of options through technologies.

We provide caveats for guidance at the interface of social-ecological and socio-technical systems by investigating the role of innovation. This we frame

by differentiating social innovations and roles on the one hand and technological innovations and rules for socio-technical governance on the other; also their mutual intersections as well as their possible (in)direct interactions with and ramifications onto ecological systems. A frame for society-technology interactions under the concept of commons or common pool resources (CPR) is developed. We do so across the tension of solidarity and sovereignty using the example of a co-prosumer in an electric energy infrastructure supply system.

According to [1], the last century brought with it a new invention on innovation processes, namely, the belief that everything that can be done, should be done. This is relevant for the employment of individual people as well as of collective institutions in society enabled by technology infusion because a questioning about which range of potential options should be employed is important from an ethical and moral philosophy point of view. Based on insights about options for the interaction of society with technology, we conjecture how to frame lessons onto current debates about the involvement of cyber-physical systems into everyday life (distributed view) and onto their governance (aggregate view).

We discuss technology involvement in human affairs through a lens on its virtual interrelations for domestic electricity control systems. The goal being to find reasonable, dignified, and integral ways for the weaving of technology tools into more sustainably-designed societies. We critically reflect on the use of technologies by spanning the range of possible options in the dichotomy between empowered consumers that are given choices and the empowerment or disempowerment of prosumers through the submission to control systems that may or may not serve other interests. Which processes and socio-technical arrangements are more conducive to reaching a sort of energy sovereignty on the consumer level will be discussed.

System complexity increases with more players and interaction options in the re-design of those systems. Some visions and implementations on how to shape greener futures could be characterised as utopian. The shape this can take is across a range of collective control mechanisms versus authoritarian governance, which are discussed in [2] from a degrowth perspective of enabling and convivial technology futures and their opposites. Hereby, a utopia is not an impossible mental construct but rather

something out of the ordinary, elsewhere, or in the future – a vision on the possible range of how societies should be de- and reconstructed, structured and operated and how resources are to be employed and distributed [3,4].

Solidarity as a concept is perceivable somewhat indirectly and intangibly. To assess its presence, it might be helpful to deliberate on options for reciprocal and non-monetary and material exchange systems. Our investigation asks how to conceptualise the contributions of factors that can be steered behaviourally across the individual and collective realm. What are the consequences and effects of different system framings and how are they affected by the different levels of understanding and perspectives that come together in more diverse and aiming-to-be equitable and just system designs?

We ask how formalised rule systems emerge and could be shaped, as is one focus of institutional analysis and which can be assisted by political economy. We investigate what system representations with their underlying assumptions on power, information and control structures exist and which questions should be posed about the design of social interactions and how to link them with technologies.

The concept of an electricity co-prosumer, who would become freer by having less choices related to the manner of the relatively indifferentiable aspects of electricity consumption. This could be achieved through a once-off choice or a contractual arrangement, respecting the aim to achieve a balance across individual and collective interests, namely solidarity. This reflects our aim for a discussion about the circumstances and socio-technical arrangements that are necessary for any type of decentralised control, be it financial, technological, social, or legal. For the energy co-prosumption (ECP) frame, the level of aggregation in that different shapes of collective processes are enabled is important and has been developed in the Interrelations Between Agency and Structure in Transitions (IBAST) framework of [5].

This article is structured as follows. After a short overview of concepts relevant for electricity consumption from common pool resources according to Ostrom and their operationalisation with technology through algorithmic governance, we discuss relevant aspects from social practice theory [6, 7, 8, 9] for home energy management systems. Thereafter, we navigate from the interface of society-technology to technology-society by referring to technical and

social interconnectedness according to [10]. From those options arises a discussion on the co-provision and co-creation of infrastructures as such and their modes of operation. We end with an overview of the types of interrelations that could be made possible across human and technological option spaces. In this, we suggest the ecosystem approach as a classification for redesigning or moulding the types of relations that are possible in socio-technical arrangements for electricity. We argue for their reframing based on commons for a commons-based (co-) prosumer instead of the popular persona of the more individualistically orientated prosumer.

2 Literature review

2.1 Commons and society-technology context

To imagine the case application of the abstract concepts to be discussed here, take a local neighbourhood, in which people are deciding on the installation and operation of their water or electricity systems. These could include rainwater harvesting, greywater recycling, or the sharing of solar photovoltaics plus battery systems. The question we address with the concepts developed in this paper is what the rules of the game should be for the attribution of benefits and the distribution of relative costs. While these have been tested synthetically and practically using agent-based models or serious games, our approach fits more onto a meta-level for system design options and operational aspects such as rule and control systems, augmented by technological possibilities. For the exemplary case, how and whether to rank, rate and trace the relative contributions of the individual components of this energy neighbourhood system would need to be decided. This decision in turn determines the level of permeation of technological and ICT components to enable the system to be operated and controlled respecting shared interests. The level of self-control or outsourced control needs to be carefully considered and depends on the internal proficiency or available professionalism and the desired levels of aggregation across the structures of a community energy system.

Whenever supply infrastructures are shared, the monitoring of differing relative contributions to demand and supply becomes a topic of collective decision-making and with this, several possible ex-

change systems could be taken as a basis. Thinkable options for valuations of these exchanges could be egalitarian, flat rates, or more or less tracing and monitoring of production and use data, which might require data storage. If no equal accounting system is used, a reciprocal exchange system requires accounting systems and bureaucracy, even if simple recipes are used in the system. These aspects concern questions on the reciprocity and traceability in system governance. It is relevant to decide upon how much data is collected and what meanings would be attributed to this data.

The idea of commons or CPRs originated in natural resource systems that were extensively studied by Ostrom, who reached beyond what market and governmental approaches can offer. Her work evaluated the conditions for sustainable management of CPRs, collecting already existing alternatives to top-down approaches to governance. Despite this approach, Ostrom should not be seen as a “poster child for anti-market economists” (Philip Booth in [11], 13). She does away with the limited perspectives of textbook theorists by exposing the rich sphere of options that people in their own context come up with to solve adaptive co-management and governance issues of the resource bases that they themselves depend on. Institutions to support those self-developed processes are necessary to upkeep not only a balance, but also checks and balances in the form of rule, monitoring and retribution systems.

While Ostrom developed and applied these principles on natural resource systems, more and more voices are emerging that are interpreting technical and socio-technical infrastructure systems as a CPR that is being shared and in need to be appropriately governed. Applying the principles and lessons that can be gained from CPRs and to some extent the design principles onto the new and old players of electric infrastructure systems, Pitt and Diaconescu (in: [12]) encoded the design principles of CPRs into a frame of algorithmic governance of common pool resources. They employ adaptive institutions, distributive justice and the canon of legitimate claims onto several examples, one of them being decentralised community energy management systems. For this, holonic structures have been deliberated to be useful. ([13] in: [12]; [14])

For collective action situations, [15] address information asymmetries and other risks that can arise in self-governed socio-technical systems through digital

rule sets of Ostrom from a knowledge management strategic perspective. They achieve a fair distribution of power, aim for transparency, inclusivity and shared values also in heterogeneous collectives.

2.2 Reframing connection options and rule systems for technology-society

Technologies can carry out functions such as monitoring, mapping and tracing with associated possibilities for the control of processes. Increased socio-technical connections bear the risk and potential for a greater emphasis on individuality and separateness, while at the same time commons-based systems can develop individual as well as collective interests and support a more balanced distribution of costs and efforts. This permits a continuous growth of networks and new dependence relations based on which new agencies can arise for self-determination, governance, emancipation, and empowerment. For this, filter systems that curb, channel or catalyse the information that is being collected, shared, and used could be useful to steer sensible collective efforts with intentionality and direction towards common aims and mutual learning from the bottom up.

We suggest investigating the role of technologies in a digitalised society for building, maintaining and discarding of connections. The definition of roles and responsibilities is affected by boundaries both locally and virtually. Agency on individual and collective scales can be represented in holonic structures and across levels of aggregation, and with this under an umbrella of collectivism. With increasing importance and permeation of technology, option spaces increase for access to and processing of information, and responsibilities are thus augmented. These possibilities require a framing from different perspectives such that technologies can be inclusive, such that socio-technical systems are more enabling rather than overwhelming or disempowering, and such that sustainability aspects can be improved in socio-technical systems and the other systems they influence or interact with.

The ways in which a technology affects a social system, an economic system, or a supply and value chain can be distinguished according to several criteria (adapted from [16]). Technologies acting as obstacles (solidifying states of separateness and disorientation) are to be avoided, and the design of socio-technical systems is not to nurture self-centeredness but rather the collective good, not steering towards

dehumanisation. Furthermore, technologies are to help incentivise behaviours towards sustainability and to investigate different modes of human-machine interaction. In this, limiting the interactions and exchange systems can not only simplify infrastructure arrangements but also can, seemingly contradictory, endow human actors with some freedom precisely through inhibitions or limitations. On top of this, with appropriate designs of rules and mechanisms, fairer attributions and contributions can be enabled, appreciated and if appropriate also monetised and its benefits distributed. There is a need for limiting the use of technology instruments or tools to avoid potentially unnecessary intermingling in the social, virtual and physical spheres.

In her critique of the smart utopian vision, [8] refers to the Golem from Jewish mythology and functionally compares it to the concept of home automation technologies. This figure is similar to a slave helping around the house. The question on who controls or adapts to whom, and how instrumentalisation is taking place with technology is relevant for such an intrusion into everyday domestic practice. Similarly, in German folklore, the Cologne Heinzelmännchen are assistants or servants to people, cleaning up overnight but disappearing if they are being watched (monitored). The lesson of the allegory of such supposed helpers for home energy management systems is that these systems are not merely passive and indeterminate to human behaviour for energy consumption, but rather they “are enrolled in a dynamic interplay between who or what is in control that has implications for when, how and how much energy is consumed” [7, 8]. Thus, the ownership of data and rights around information exchange, self-determination, as well as control aspects trigger questions such as: When are technologies enabling or disabling? Should the ‘smart ontology’ of the industry especially with respect to changing demand patterns be questioned? [17] How can technologies assist in operationalising CPRs for the coordination of bottom-up and decentral energy transition processes? What are implications onto the behaviour, intentions, and valuations of energy systems, such as adaptation and demand response or flexibilisation.

To dissect the dimensions relevant for technology-society interactions, the understanding of technology also as a political phenomenon implies that the distribution of burdens and benefits in the form of

externalities is critical to consider. Externalities can occur either across social actors, across regions or time shifts and crossing generations. Hence, mechanisms to orchestrate involved processes towards more just and appropriate or considerate arrangements need to take place not only across different spatial and temporal scales, but also alongside levels of social aggregation, be it a neighbourhood, village, city or province.

Designing rule and governance systems should include a critical assessment of the real empowerment of people through technology. A trap could lie in the unnecessary shifting of responsibilities when social and technical dependencies are reconfigured. Agency and responsibility allocation are discussed by [18] and applied to a new role system onto energy citizenship or even sovereignty. The crossing of levels of agency is also positioned in relation to similar research on the co-emergence of new structures by the extension of mere individual consumer agencies away from merely end use or interaction with a smart home environment, to involvement in cooperative structures and thus collective empowerment.

Examples of how transparency is created of monetary control flows in the energy landscape are the German StromDAO, who enable bottom-up partaking of individuals. Compared to them, the Bürgerwerke are a conglomerate of energy transition cooperatives, bundling opportunities and working with intermediaries for direct marketing of electricity. For the operations of StromDAO as well as the aggregated energy coop to work, virtual processes as well as ICT are necessary. How much coordination is necessary and what happens on individual and collective scales and how to encode these into contractual arrangements affects sovereignty, dominance and self-determination. How sociality and the interactions between human-environment and technology are affected by information sharing and access to information with associated risks of abuse are critical questions, as evaluated in a case study from the U.K. by [19]. If we were to use the terminology of [18] onto those two examples; while StromDAO enables participation of emancipated consumers on market and financing of electricity, the Bürgerwerke additionally enable active citizenship on a more collective scale and with this also agency in terms of policy and politics.

The types of social and technical interconnectedness, and thus the relations of sub-compartments

to the whole system, were categorised by [10]. The degrees of technical and social (dis)connectedness affect the level of self-sufficiency that is required, with one extreme case being off-grid technologies. On the other hand, high-tech solutions are needed for technically as well as socially highly connected system designs. In the old energy infrastructure system, which we are transitioning away from, there were captive consumers, monopolist providers, and non-renewable resources. The traditional utility relationship between individual customer was broken through deregulation and liberalisation of the industry. Through this emerged a disparity in size of players that interact for production and consumption and a differentiation of resource use, providers, mediating technologies and consumer roles.

More opportunities arise for co-provision given the new players, role and rule systems [20], thus transforming the captive consumer into a customer-consumer, citizen-consumer, or even co-provider. The range here is across increasing levels of self- and co-determination comparable to political maturity, in German Mündigkeit, which refers to having a voice in the sense of real or operationalisable agency in a given context. As co-designers and co-creators of value, the boundaries are flexed. The option space is widened about what is socially versus what is technologically negotiable or even acceptable. We ask how those two spheres could interact and which relational types could characterise the interactions. The new relations and exchange options that Finnish prosumers have were described by [21] and participatory methods for better understanding the potential behaviour were suggested. However, if such prosumer roles are framed within a co-prosumer angle, this has implications onto the system logic and coherence and consequences for how individual and collective benefits could be dissected and woven together again. In the next section, the system structures and fitting in of the co-prosumer role are presented.

3 Governance and structural options in infrastructure systems

3.1 System structure, aggregation levels and relational options

If we start from an individual unit, autarchic in the most extreme case, and go step by step through sev-

eral layers of aggregation, it implies that relations become necessary. The first type of a technologically and socially disconnected individual unit would be an off-gridder (for examples see the book review of [22]). In this scenario, one takes utility services into one's own hands at the smallest scale of provision and with theoretically no need to interact once systems are installed and assuming one can self-maintain them. A scenario setting, where one would have the choice to connect, but decided to stay secluded from a surrounding existing infrastructure system, could be termed dissociative and de-solidarising due to associated individual and collective consequences. Supply is achieved from own resources and the price of self-sufficiency is either scarcity and supply interruptions or a high level of redundancy and thus luxury and significant investment required to provide ample storage systems to make sure one does not 'run out'. The question for this individualistic setting is whether every person would actually feel empowered and satisfied to be this freely self-responsible, if really one is able to create and maintain such a system given associated necessary infrastructures and capabilities.

If we go further into connected systems, dependence structures are immediately occurring and control and information flows that come with such systems require decisions about causality and determination. Contractual arrangements providing a suitably crafted service arrangement or pre-designed systems of provision for electricity or other infrastructures determine the level of technology involvement and the ways in which these are realised and their scales of management. Depending on the setting of boundaries, subsystems or elements are in- or excluded, affecting externalities. Those relate to the distribution and shifting of benefits and burdens. Another way to represent the system structure for electric systems is a cellular design, for which open questions need to be ascertained about how to design local or decentralised markets amongst individuals, peers, or aggregations thereof in sub-compartments of the system.

We abstract this onto the interrelationships of technology and society. Given the potentially hazardous dependence structures that can occur in technology lock-in situations, it is reasonable to question the net benefits of the smart ontology by asking: Just because we can do something, should we really? Data collection, storage, sharing and controlling of infor-

mation in critical infrastructures goes well beyond mere privacy issues. The question of what an appropriate choice is on an individual as well as collective level is non-trivial to answer for critical infrastructures and dependent on one's system's physical and social boundaries as well as mental frames.

3.2 Fitting the co-prosumer role within ecosystem theoretic boundaries

Coming to electricity systems for domestic practice, an invented persona - in a way an antagonist of our co-prosumer - described by Strengers [9] and taken up by [23] is the so-called *resource man*, an individualist and engineer-type white collar male, who rejoices in having control at his fingertips. He indeed is and would be the ideal agent for the smart industry narrative because he could be a textbook prosumer, remote controlling his home and appreciating home energy management systems connectivist functionalities. In [8], this smart utopian vision is questioned from several angles in her investigation of the negotiability or non-negotiability of domestic practices.

She frames social practices and implications for electrical and energy infrastructure systems, and identified a "need to extend the ontological realities in which smart technologies and their associated strategies are imagined and work" [8, 9]. While there is no one way in which this occurs, multiple realities can and do exist in the interrelationships between technology and society. A co-prosumer would fit better into the vision of [10], where infrastructure service provision involves "distributed generation, network integration and co-provision." [10] (pp. 110-111) Thus, the concept of shared as well as co-responsibilities has already been framed a while ago. These could become a reality on wider scales, supported by technology options that are more and more permeating societies.

Sketching a frame for interconnection options for the ways that actors in the system relate to each other, ecosystem theory and theoretical ecology can be made useful. We suggest its use such that one can reach beyond descriptive metaphors such as the energy cells (sub-systems or compartments) or the cellular approach that is oft-discussed in Germany [24]. Another parallel from ecology are symbiotic relationships mentioned by [5] to describe collaborative interaction between energy cooperatives in Germany.

The types of interconnection options across socio-technical contexts and different preconditions and scale economics across hierarchical levels should be critically examined. Using ecology concepts for sustainability agendas, [25] (p. 77) suggest that it is “important that two or more hierarchical levels are co-operating, not the higher level controlling the lower levels, as it is sometimes the case in management hierarchy. Control – instead of cooperation – always gives occasion to an increased bureaucracy, which wastes human and material resources.”

The label of a co-prosumer has been mentioned in an innovation and business management context by [26]. Other terms used by [26] and [27] include co-innovator, co-designer and co-creator of value. While for [26], the role of the consumer and extension of this role as a producer seems to imply not much more than common responsibility shared among a company and a prosumer, the prefix co- does not relate to Ostrom-style commons logic. Our suggested co-prosumer not only refers to the CPR approach, but also to commons-based peer production and co-creations across wider levels. These are also debated for electricity innovation management by [28], who go further to elaborate on the intrinsic and extrinsic motivations of active participants in innovation ecosystems. Top-down and bottom up processes in innovation diffusion for smart grid infrastructures are distinguished by [29], highlighting the importance of larger societal and regulatory factors that affect the success of co-creative and prosumer roles. For the engagement of consumers for electric demand response programmes, [30] discuss power aspects, access to and control of information, regulation and the role of and options available to intermediaries. Independent dispute resolution mechanisms are required besides appropriate contracts that map the envisioned new role and rule systems.

From a technology and commons-based perspective for an open source society, [31] revisits the tragedy of the (uncontrolled) commons and transfers these principles onto technology-intensive infrastructure systems. Regulation seems to be called for to avoid the complete collapse of functionality of a CPR such as the mobile telephone network. To the role of politics, privatisation, auctioning and regulation he adds what he calls a missing link provided by Ostrom-style CPR governance, including clear boundaries, the possibility to change rules, and collective monitoring and retribution mechanisms. The internet

is taken as an example of a highly complex CPR of knowledge for the digital information economy. Digitalia mostly are not characterised by rivalry and are part of a “*magic cooking pot*” of knowledge commons. The copyleft principle and commons-based peer production are part of the open source movement that created a culture of collaboration that incorporates open designs and blueprints that are able to help stir open innovations. The shadow side of these new possibilities are challenges of intellectual property and digital rights management, where control mechanisms that were originally intended to incentivise innovation have now turned to become a method of top-down control.

Concepts around top-down and bottom-up control systems spanning several disciplines were discussed by [32]. Inferring from the mere translated meaning of the word hierarchy, he juxtaposes different interpretations of control types and system structures across biological ecology, sociology, social ecology and political theory such as antihierarchic revolutionary interpretations. Ethical constraints and terminology are applied to nested power relationships and ruler and ruled relations. Taking a stance based on systems theory, [33] progressed work based on [34], who in turn suggested a way to navigate between holistic and reductionistic perspectives. In this, he used the concept of a holon to define a structure as *Self-regulating Open Hierarchic Order*, or SOHO. This acronym was referred to by [32] as Self-Organising, Holonically nested, and Open (SOHO) entities or beings.

SOHO conceptually refers to structural aspects about subsystems, their relative autonomy and authority, rule systems and strategies of evolution are described in terms of their negotiability, non-negotiability and flexibility across levels. Specific rules are associated with structural and functional aspects, concepts from ecology that can be transferred onto socio-technical systems alike. Koestler transfers these principles to behaviour in social contexts and ends with a canon, or a systematic set of axioms and propositions relating in detail to cross-level hierarchical structures [34].

For ecosystem theory to address socio-technical system structures, the parallel principles and characterisations of what a species entails would need to be described. The aims, intentions and degrees of freedom in the behaviours and the environments and contexts from which resources are used and shared

can be more clearly distinguished in a human-made technical system. If we look at different types of networks that could play a role for the system design, options could include mutualistic, symbiotic, parasitic, predatory or facilitation, commensalism or mutualism types of relationships. These types affect who benefits how and on which level and whether components are able to survive in the short (small temporal scales), medium (life span of organisms), or long term (evolution and species).

If we transfer this onto political economic questions across levels, interactions on individual and collective scales as well as on physical infrastructure systems need to be appropriately assessed to be able to be coordinated. With more system components and more versatile roles that can be played, there arise also more interaction possibilities. This increases the system complexity and thus finding appropriate coordination or rule systems becomes more challenging as system structures adapt to new technological functionalities. From formalised rule systems such as what is or could be encoded in legal systems, incentive systems can be designed that impact the directionality of causality, or determination and control in infrastructure systems.

4 Summary and discussion

Summarising, we aimed to strengthen sustainable and resilient systems by proposing options on how to realise co-responsibility for technology applications that invade the privacy of the household. Through this, at the same time we suggest hope as we propose to curb the full potential of permeation of technology options in infrastructure systems. Additionally, cautioning around innovation in sustainable societal transition processes by debating the (dis)enabling roles of technology for social solidarity were our points of focus. We provided arguments that are useful for cooperative and participatory approaches in infrastructure systems of provision with the focus on roles that can be played on individual levels or on peer-to-peer (P2P) networks. However, an ecosystem-theoretic approach that can represent structural and functional as well as different role and rule systems for interactions amongst system participants permits even more differentiations and the augmenting of the P2P concept into how subsystems (S), aggregations (P), or individuals (I) relate to the whole system. This can qualify the type of feedback

loops that would then be schematically described as follows:

- P2S – S2P: How do peer structures and other subsystem structures interact amongst each other and with the whole system?
- I2S – S2I: How do individual subunits relate to subsystems components?

5 Conclusions and outlook

We suggested common pool resource logic as a basis for incentive systems that balance individual and collective burdens and benefits. In this context, energy co-prosumption (ECP) would be more appropriate to be incentivised instead of the potentially detrimental prosumer because looking at the repercussions that the latter induces to the system, benefits neither really arise for his own nor for the system sake if assessed from a more holistic system-level angle.

The energy co-prosumer could also be framed for other infrastructure supply systems and will need to be framed or embedded and considered within systemic structure options. Ultimately, it is desirable to reach an appropriate design of incentive systems that could go beyond a mere nudging of prosumers to become co-prosumers. We are not necessarily saying that all prosumers must or should be co-prosumers, but, we wish to establish in more detail in future the implications that more co-prosumers would imply across system levels, should this persona be nurtured. With such a systemic view as we have proposed, it would be possible to create offers that are very difficult to resist and hence decisions and preferences on the individual level could be developing in a more commons-logic based fashion.

Control systems that could be based on a framing of the interactions across levels need to consider different options for determination. Determination in this case refers to self-determination on the one hand, and determination by and for others, referring to collective sub-structures. If the individual subunit views self-determination also as a part of a larger sub-structure, then the distribution of costs and benefits of system design and operation can be allocated accordingly and value would be seen in a different light. Voluntary contributions such as sufficiency or flexibility, which impose some smaller scale disadvantages but larger-scale advantages that feed back onto the smaller scales potentially with a

time delay, could be seen in a more positive light, and thus, could gain some momentum.

Following the argument around the combination of hedonism and sufficiency [35], the concept of alternative hedonism could inspire the roles not only of the human agents in a socio-technical system, but also the role of technologies and digitalisation as such. The concept of alternative hedonism and consumption as a political tool was framed by [36]. The involvement, participation and use of smart energy systems and cooperative structures could equally well be an “act of political identification” [36]. It would be helpful for the adaptive and potentially even incrementally transformative redesign of a socio-technical system to reconsider the choices on individual and collective scales and their repercussions if aggregated. The success of the “hedonist imaginary” [36] is dependent on the “emergence and embrace of new modes of thinking about human pleasure and self-realisation”.

Intrinsic motivations coupled with pleasures in alternative pathways – frame a sort of appropriate technology and minimalism related to the potentials and hazards of technology-society interactions. This can impact the modes for meeting needs, and the modes of consumption. These, in turn could be transferred to modes of operation and assist to achieve sufficiency collectively. This can be realised with the aid of technology because potentials can be made visible faster and governed more appropriately.

Intentionality and as much as possible being aware of causalities in system design and operation and how these are affected by the purpose or role of technology integration are key points to consider. Given the extended toolset proposed by technology that we aimed to critically discuss and normatively align in this article, some questions arose that could be investigated in future. These involve questions around how values are assigned and the setting of aims for an individual or a collective. Furthermore, to ask what are the possibilities in infrastructure arrangements and what aspects need to be (re-)negotiated as well as co-assembled?

Positive examples at the science-technology interface are tools that can enable learning and system understanding in participatory processes [37] such as interactive mind mapping tools¹ or visualisation tools for determining the phases of human processes. Complex decision processes for self-organising pro-

cesses are described and guided with a technological tool² by [38], developed for monitoring progress in psychotherapy.

The risks with leaking of sensitive data for vulnerable (medical patient) groups are to be carefully considered, given that the tool mentioned above was developed just before massive data sharing technologies were permeating societies. Therefore, infrastructure systems should ask questions such as: benefits for whom, at the cost of what, and what could be side effects now and in future?

Coming back to the frame of responsible technology permeation through society and the need to accept or reject it in a differentiated manner, this work highlighted strategies for discerning the dosage of how a technology can be appropriate and in line with a socially robust purpose. Those enabling software tools help steer and trigger processes of high value to mental health and participatory design processes. Even though they require significant monitoring and transparency, despite their invasiveness their shared purpose and aligned consensual intentionality and potential results make them worthwhile in the appropriate context.

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