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SPECIAL FEATURE: EDITORIAL

Individuals within the Larger System to Support the Energy Transition

Understanding the embeddedness of individuals within the larger system to support energy transition

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Abstract

CO_2 emissions need to be reduced drastically to fight climate change and minimise the further increase of average global temperatures. The decarbonisation of the energy system aims at reducing CO_2 emissions and is thus urgently needed. This transition is facilitated by inter alia switching to renewable energy sources and more efficient technologies. In the past, the energy transition has mostly focused on supply-side measures. However, at least since the publication of the 6th IPCC assessment report, demand-side measures have gained attention. Thereby, the roles individuals play in achieving this transition is recognised as important. This Special Feature is dedicated to exploring the roles of individuals within the energy transition. The nine thematically featured articles provide insights on this topic using different foci and angles, such as the information to guide individuals' behaviour, the influence of media in framing roles, and technology acceptance. To contextualise and synthesise these diverse contributions, this editorial introduction outlines three different, complementary clusters of roles: technology adoption, lifestyle choices, and political action. By theorising users as participants in transitions through diverse practices, we widen the basis for future research to address and incorporate the roles users play in engaging with and shaping these transitions.

Keywords Energy transition · Agency · Energy citizenship · Technology adoption · Low-carbon lifestyle

Introduction

The energy transition aims at decarbonising the energy system, thus reducing the CO_2 emitted (Apostu et al. 2022). Hence, it is a necessary process towards limiting the temperature increase to 1.5 °C, if we are to avoid the associated catastrophic consequences of this extent of global warming (Hainsch et al. 2022; IPCC 2022). The current understanding is that we have already breached a global average temperature increase of 1.1 °C (IPCC 2023, p. 42). Reports of the Intergovernmental Panel for Climate Change (IPCC) provide scenarios that give insights into the changes necessary to not overshoot the 1.5 °C threshold (IPCC 2022). The needed changes are substantive and encompass demand and supply-side measures. Thus, the energy transition is on the one hand about shifting to alternative primary energy sources (supply-side) and overhauling the supply chains to secure the energy supply. On the other hand, it is also about reducing energy consumption on the demand side (Kuzemko et al. 2017). On the supply side, decarbonising the energy system

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means switching from non-renewable to renewable energy sources. On the demand side, reducing CO_2 emissions can be achieved through the adoption of low-carbon technologies in all sectors of society, through efficiency gains in those sectors, and through lowering energy consumption and bringing flexibility into the temporal rhythms of energy usage and storage. For individuals,[1] this means the adoption of low-carbon lifestyles. The 6th assessment report of the IPCC (2022), for the first time, captured this lifestyle-related demand reduction, spotlighting the actions that individuals can take to reduce energy consumption. Therefore, in November 2022, we published a call for papers for a Special Feature to investigate the embeddedness of individuals to support the energy transition (Biely et al. 2022).

With the increasing attention to the role of individuals in supporting the energy transition, discussions about burden shifting have started. The individualisation of the energy transition bears the risk of placing the burden of action on individuals (Baatz 2014; Lennon et al. 2020). While everyone's actions count, individuals are part of an energy system that is embedded into a social system. Hence individuals' actions are bound by systemic structures, norms, rules, and regulations. The focus on the individual level should not be co-opted to shift the burden onto individuals. Clearly, the energy transition requires concerted efforts of all players involved: civil society, governments, and businesses (Kern and Rogge 2016). Despite the great potential of demand-side options to reduce CO_2 emissions, many of these solutions connect to a given infrastructure or design (Creutzig et al. 2022). The infrastructural design and institutional structures of the energy system not only determine the magnitude of potential demand-side reductions but also the roles individuals can take within the energy transition (Thombs 2019). This editorial introduction expands on these interrelationships below and articulates a tripartite categorisation of the roles users play during transitions.

Roles of individuals in the energy transition

In emergent research, Robison et al. (2023) identified "100 priority questions to accelerate sustainable energy futures". Among them, there are several related to the role of individuals: 19 are about the roles of consumers, 15 about energy communities, 23 about democratisation, inclusion, and participation, 21 about lifestyles, 18 about behavioural change, and 12 about power and politics. Thus, this Special Feature is a timely contribution to energy transition research. Dunphy and Lennon (2022) differentiate between two main influence spheres of individuals: the market and the political. The roles individuals take within these two arenas can be identified by behaviours. In the market sphere, these behaviours are consumption, renouncing consumption, as well as producing and selling energy. In the political sphere, individuals can act by participating in decision-making processes or advocacy work. Of course, these spheres and behaviours are linked. For example, one can frame renouncing consumption (e.g. not flying) as a political act (Knox 2022). One can also differentiate between active and passive roles of individuals, such as passive and active consumers, prosumers, collective producers, citizen investors, citizen activists, and those who are excluded from any form of participation (Dunphy and Lennon 2022). These categorisations overlap with the categories developed by Thombs (2019). Investigating energy transition pathways, Thombs (2019) distinguishes between "(1) libertarian energy decentralism, (2) technocratic energy centralism, (3) democratic energy centralism, and (4) democratic energy decentralism". These four future scenarios evolve along two axes, the market and the political. The polarities of the axes determine the degree of participation. In the technocratic energy centralism scenario, individuals remain passive on both dimensions, whereas in the democratic energy decentralism scenario, individuals are active.

Many different behaviours can be ascribed to individuals' roles within the energy transition (Laakso et al. 2023a; Vogler and Kump 2023, in this issue). In the following, we distinguish between three types of behaviour: technology adoption, lifestyle choices, and political action. These behaviours show up in different roles, including the prosumer role of solar panel owners, or the role of activists. However, the existence of certain roles and whether individuals can take them up depends on several factors, such as the energy system structure. For example, an energy system where individuals can assume the role of the prosumer needs to have structures that allow decentralised energy production. Furthermore, the framing of the energy system might limit the roles of individuals to consumers. By contrast, changing energy infrastructures and introducing new business models may render behavioural and lifestyle changes easier. As an example, the combination of various enablers and drivers can allow prosumer flexibility and boost decentralised generation models (Gough et al. 2020). The introduction of new structures might also support the democratisation of the energy system, which would allow individuals to take political roles.

Before introducing the scientific articles of this Special Feature, we delve deeper into the three role clusters: technology adoption, lifestyle choices, and political action. This section finishes by outlining some overlaps between these roles. Thereafter, all nine articles of this

[1] The term individuals includes consumers, energy users, households, as well as citizens.

Special Feature are introduced. In the subsequent section, we elaborate upon the insights provided in this editorial introduction. Finally, the editorial introduction concludes by highlighting the timeliness of this Special Feature and the timeliness and importance of a systematic body of research about the diverse roles of individuals within the energy transition.

Technology adoption

The energy transition implies changes to the demand side with respect to the technological systems that are used. Individuals may need to choose alternative (more efficient) technologies and/or alternative (renewable) energy sources. There is a vast literature about such choices, both the factors impacting choice as well as how the context affects these choices. Technology adoption diffusion theory explains that new, improved technologies gradually penetrate society, and do not diffuse all at once (Rogers 1983). For a technology that diffuses fully, it starts with so-called innovators and early adopters. Afterwards, the early majority and late majority consumers adopt the technology. But which technologies diffuse depends on many factors (Chappin et al. 2020; Hesselink and Chappin 2019). Consumer choices are impacted by the available options and their performance in the local context. Uncertainties about the options and their performance now and in the future affect choices as well. The interconnected nature of energy systems (i.e. energy supply and transition systems, buildings with their features) and the plurality of energy policies in place further complicate the decisions made by individuals. Because of the large and wicked structural changes that can be anticipated during the energy transition, all of this is highly in flux, and this volatility in turn affects the ability and willingness of individuals to make choices.

Over time, the adoption of technologies in the energy transition faces complex dynamics, with many interacting factors. This shortens the time horizon in which individuals can consider making informed choices. Consequently, some technologies may induce rebound effects where actual improvements will lag behind expectations (Berner et al. 2022; Guzzo et al. 2023). Boomerang effects might occur when technologies are not well introduced. That is, developers might expect adoption or improvements because of the positive envisaged impacts of their technology, but psychological mechanisms (such as a lack of trust in the developer) can lead to resistance and unanticipated effects instead of expected adoption (de Vries 2017). The contribution by Onencan et al. (2024, in this issue) indicates that despite citizens favouring the installation of district heating in their apartment building, fears connected to this unknown technology might inhibit residents' agreement to the energy retrofitting plans. Competing technologies and the difficulty of finding understandable information about technology options may hinder adoption (Palm and Eriksson 2018).

Due to the socio-technical nature of energy systems, not only technical difficulties but also social aspects (e.g. social opposition (Sovacool et al. 2022) and cost-effectiveness versus justice (Bang et al. 2022)) can impact the socio-political feasibility of transitions. Such factors drive complex dynamics that condition rates of adoption and flows of benefits to a changing field of actors through contestation and positioning under uncertainty. Overall, technology acceptance is a dynamic process with many different actors with flexible responses (e.g. Kluskens et al. 2024, in this issue).

The energy transition is often viewed through a socio-technical lens (Li et al. 2015; Sovacool et al. 2020). Socio-technical transition theory proposes that a transition starts with a niche innovation. A successful transition is characterised by a breakthrough and hence widespread adoption of that innovation (Geels and Johnson 2018; Verbong and Geels 2007). The adoption of new technologies is facilitated through market mechanisms and political support (Hoggett 2014; Tagliapietra et al. 2019). For example, the recent cost reduction of solar PVs (and similar technologies) increased the affordability of and thus demand for these technologies (Green and Newman 2017; Swilling 2019). Subsidies and investments by governments can create favourable market conditions (Buchholz et al. 2019; Swilling 2019) and overcome the resistance of incumbents (Snick 2016).

Technology adoption is therefore accompanied and/or prepared by changing regulations and structures. As these innovations are socio-technical in nature, they also lead to changes within the social system. However, this lens can reduce the role of individuals to technology adopters and consumers (Nijhof et al. 2022): individuals may represent passive subjects to the energy transition driven by regulatory authorities and industrial incumbents, rather than actors with bottom-up agency (Kivimaa et al. 2021; Lennon et al. 2020). Although the energy transition will undoubtedly require innovations and their widespread adoption, as the 6th assessment report of the IPCC (2022) indicates, there is more to it. Focusing on technologies and limiting the roles of individuals to the consumer might reduce the effectiveness of transformative technologies (Dunphy and Lennon 2022). For example, if behavioural aspects are not addressed, rebound effects might cancel out efficiency gains (Exadaktylos and van den Bergh 2021; Reimers et al. 2021) or the technology can be resisted (de Vries 2017). Not including individuals in the decision-making process might reduce individuals' acceptance of renewable energy projects (Jehling et al. 2019). Framing individuals as consumers also

excludes those individuals with less financial means (Hanke et al. 2023).

The focus on technology might create a feeling of apathy, as an individual might not be able to influence technology development (Lennon et al. 2020). Individuals might not be in a position to adopt certain technologies because of their limited income. Consequently, they might be left to wait for others, such as governments, to make the necessary changes (ibid). Switching from a combustion engine to an electrical vehicle (EV) requires one to have the necessary funds and access to infrastructure (such as charging stations at home) (Sovacool et al. 2019). Similarly, the installation of solar panels or retrofitting to reduce energy demand requires funds (Carrosio 2021). Furthermore, such actions might be limited to homeowners (Galvin and Sunikka-Blank 2017), excluding tenants (Hanke et al. 2023). Thus, technological options to tackle climate change might neglect socio-economic factors and thus maintain socio-economic disparities (Kraaijvanger et al. 2023; Thombs 2019). Therefore, the development and support of technological solutions have to address these factors. For example, the design of technologies that can be used by tenants may provide one way forward (Trenks and Bögel 2024, in this issue). Shared energy production and storage models could also be an option for tenants (Green and Newman 2017). Given the importance of socio-economic factors in the energy transition, it is not surprising that issues around energy justice and energy poverty have become increasingly studied research fields (Galvin 2020; Herrejón et al. 2023).

Purely looking at the technological side of the energy transition limits the scope of action individuals can take, where the scope is determined by one's income or assets. That might equip the wealthier part of the population with more agency in the energy transition. However, as Jack et al. (2023, in this issue) show, individuals with lower income might grant a greater scope for action through lifestyle choices.

Lifestyle and behavioural change

The energy transition not only requires the adoption of new technologies, but individuals also need to change their behavioural patterns (Wiedenhofer et al. 2018). That is, they need to adjust to the fluctuating supply of renewable energy sources, such as wind, solar, water, or geothermal heat. Without sufficient storage capacities, energy gets lost if not used when available (Chantzis et al. 2023). Hence, without sufficient storage capacity, people should use energy when it is available. For example, solar panel owners should turn on their household devices, such as the laundry machine, when the sun is shining (Trenks and Bögel 2024, in this issue). Moving electricity consumption to a different interval of time is called load shifting. Insights from behavioural science, indicate that load shifting can come with challenges as practices (e.g. doing the laundry) are intertwined with other day-to-day activities that might be difficult to change (e.g. doing the laundry in the morning before going to work) (Friis and Haunstrup Christensen 2016; Korsnes and Throndsen 2021).

Another example of a behavioural change is combining the use of electric vehicles with the adoption of PV panels, which could offer the right combination of technologies to generate and store renewable energy, thus contributing to optimisation and reduction in energy use (Pelka et al. 2024, in this issue). The contribution in this collection shows that relinquishing control over charging logics can enable vehicle users to reduce charging costs, by offering service providers greater leeway to benefit from energy flexibility and transfer part of this advantage to the user (ibid.).

Pertaining to behaviour change to reduce energy use, we can learn from the past. One paper in this Special Feature enriches energy transition literature with insights from memory studies, based on a historical case study on the role of housewives in the energy transition to gas and electricity in Dutch households. It concludes that individual agency in energy transitions moves beyond choices of use and consumption. Rather, it rests in individuals' ability to identify with a historical narrative that adheres to the way the individual makes sense of the world (ten Berge 2023, in this issue).

Apart from changing isolated behaviours, individuals can also adopt a low-carbon lifestyle to contribute to the energy transition. In reference to the aforementioned rebound effect, studies indicate that consumerism can reduce or remove the positive effects of technological advancements (Wiedmann et al. 2020). Against this backdrop, low-carbon lifestyles are an essential leverage to tackle climate change and support the energy transition. Though the needed changes are substantial. Literature on 1.5 °C lifestyles indicates that footprints in developed countries need to be reduced by 80–93% by 2050 to achieve the 1.5 °C degree target of the Paris Agreement. Even lower-emitting countries need to reduce footprints by 23–84% (Akenji et al. 2019).

Promising low-carbon lifestyle options goes beyond the energy domain, and connect to all areas of life such as nutrition (plant-based diets), housing (reduced living space), or transportation (biking, car-sharing) (Akenji et al. 2019; Haarstad et al. 2022; Wiedmann et al. 2020). While the prevalent socio-economic system widely supports consumerism, the energy transition will require a transition to a system that favours low-carbon lifestyles (Akenji et al. 2016; Wiedmann et al. 2020). Such lifestyles support sufficiency (Samadi et al. 2017; Verfuerth et al. 2019), voluntary frugality, or minimalism (Anttonen et al. 2023; Jain et al. 2023). They are nonetheless compatible with *the good life*, defined not based on high consumption, but rather

on meaning and value as something intangible beyond a base necessary level of material well-being.

Nevertheless, low-carbon lifestyles might be perceived as regressive. Previous energy transitions relate to increasing mechanisation of, e.g. household chores (ten Berge 2023, in this issue) or mobility (Geels 2005). Reverting to human power and slowing down processes might appear like going back to pre-industrial times. In the current consumption-driven socio-economic system (Wiedmann et al. 2020), reducing consumption might seem like stealing people of their well-being. However, demand-side solutions do not necessarily reduce well-being (Creutzig et al. 2022). Yet, adopting a slow lifestyle and practices that rely on human power is recommended by the literature (Akenji et al. 2019; IPCC 2022, 2023; Wiedmann et al. 2020). The most prominent example is choosing the bicycle over motorised means of transport. Travel is yet again an example of slowing down and contributing to reduced CO_2 emissions. Choosing active or collective transport modes over personal automobility to commute, and choosing the train over the plane for short to mid-distance travel, are options that not only save emissions but also slow life down (Dickinson et al. 2011). While mechanisation might lead to time savings, it can intensify consumption, which can increase energy use (Jalas and Juntunen 2015). Thus, slowing life down and working less can be strategies employed to support the energy transition (Larsson et al. 2019; Wiedmann et al. 2020). Slowing down goes hand in hand with explicating our connection to earlier societies (learning from history), who worked with sophisticated understandings of sufficiency, and still do in many parts of the world. Working less can be a core constitutive element of the energy transition, both helping rethink purpose and meaning, and also slowing down global and local metabolisms and material throughput of societal activity (Kallis 2013). Reducing working hours serves to counteract the dynamics created by an economic system that requires continuous growth (Wiedmann et al. 2020), and thus reduces CO_2 emissions.

Lifestyle is also important for energy justice and wealth distribution (Baatz 2014). The analysis by Jack et al. (2023, in this issue) illustrates that wealthier people have a higher footprint than those with less income and assets (see also: Wiedenhofer et al. 2018). The carbon-intensive lifestyle of the wealthy proportion of the population contributes most to CO_2 emissions while the effects impact the lives of the least wealthy people most adversely (IEA 2023; Teixidó-Figueras et al. 2016). Thus, income inequalities translate to inequalities of who bears the burdens of climate change.

Political action

In a fuller understanding of just energy transitions, individuals are not only consumers but necessarily political actors. Demands to move away from incumbency and share the benefits of energy system reconfigurations in low-carbon transitions have to come from mobilisation among those most marginalised and disenfranchised in historical energy system governance, namely households, and citizens.[2] Political engagement can take many forms, ranging from a call for greater downward accountability (through protests, electoral votes for party agendas, and engagement in public debate) to more hands-on efforts to establish energy communities and bring the possibilities of distributed energy systems to life within emergent enabling legislation for more local ownership and control over low-carbon energy infrastructure.

The current energy transition has revived the role of energy users as (collective) energy producers (Inderberg et al. 2018). Prominent technologies, such as solar PVs or small wind turbines and mini-hydro generators, allow for small-scale renewable energy production. This enables individuals to produce their own energy, and permits the decentralisation of energy production (Mehdinejad et al. 2022). These power generation technologies can be effectively combined with heat pumps and electric vehicles, covering all the energy needs of a community. Individuals and communities are no longer only consumers, but prosumers. The decentralisation of the energy system can impact power structures and lead to the democratisation of the energy system. Ownership and power structures can change or have the potential to change (Brisbois 2019). Democratisation would imply a more active role of all citizens, where citizens' engagement is not limited to the consumer role (Lennon et al. 2020), but reconfigured as active participants in, e.g. energy communities.

However, not all renewables (e.g. concentrating solar power, hydropower plants, wind farms) allow for small-scale operations. Furthermore, renewables do not necessarily have to operate on smaller scales (Thombs 2019), although even in these cases a democratisation of the energy system could be supported through citizen participation (Dunphy and Lennon 2022; Ringholm 2022). Relevant concepts are energy citizenship (Laakso et al. 2023a, b; Wahlund and Palm 2022), energy communities (Bauwens et al. 2022; Brisbois 2019), or energy commons (Swilling 2019).[3] The

[2] Using the term citizen might lead to the exclusion of those who do not have citizenship. However, we do not intend to exclude certain individuals when we use the term. Thus, the term citizen is viewed in reference to global citizenship, rather than national citizenship.

[3] Energy citizenship and these linked concepts and concerns are increasingly attended to in projects funded by the European Commission, which can be consulted in the Cordis database using this search string: https://cordis.europa.eu/search?q=contenttype%3D%27project%27%20AND%20(%27energy%27%20AND%20%27citizenship%27)&p=1&num=50&srt=Relevance:decreasing.

democratisation of the energy system relates to questions of citizen involvement in energy projects. Apart from individuals installing renewable energy technologies, governments can choose to integrate individuals into the planning and development of renewable energy projects. Kuzemko et al. (2017, p. 59) argue that by including individuals in energy transition projects "[…] citizen groups become part of and invested in sustainable transitions, instead of a sustainable transition being something that is done to them." Kluskens et al. (2024, in this issue) discuss citizen involvement in different stages of the process and how this influences citizens' acceptance of local energy projects. (Swilling 2019, p. 228) argues that the energy transition could "potentially create the material base for a new kind of progressive politics of the commons." The concept of renewable energy commons is about "locally controlled communal ownership [of renewable energy infrastructure and technology] and solidarity [among community members]" (Swilling 2019, p. 229).

The notion of energy democracy is complex; thus several interpretations and concepts of energy democracy exist (van Veelen and van der Horst 2018). Within these concepts, further sub-categories can be recognised, each of them having their own foci (Dunphy and Lennon 2022). The roles individuals can take within each of these concepts differ. For example, the roles of individuals in a participatory decision-making process are different than in energy communities. In the latter case, individuals will typically have greater ownership and control over the whole process. Through the democratisation of the energy system, the focus of operations could move away from monetary profits to community well-being (Eklund et al. 2023). Brisbois (2019, p. 152) argues that "[as] CE [community energy] actors capture greater market share, these fundamental differences in distribution of resource ownership and business motivation have the potential to transform entrenched socioeconomic and political regimes".

The roles of individuals within the energy transition depend on various factors such as the energy resources used, the technologies employed, the scales at which the technologies are employed as well as the respective structures created (Jehling et al. 2019; Thombs 2019). Structures determine whether certain roles can be taken up by individuals or not (Brisbois 2019; Dunphy and Lennon 2022). In centralised energy systems, energy citizenship might not be an available role. Or certain roles might only be open to individuals with a high socio-economic background (Thombs 2019). Dunphy and Lennon (2022, p. 432) point out that "energy systems, as they exist today, [are] developed in tandem with society, both responding to and actuating societal needs and demands." Through the democratisation of the energy system, a democratic system can be designed that meets the needs and demands of a sustainable society.

By highlighting the political aspect of the energy transition, the active roles of individuals within this transition process become more pronounced. Individuals are not just subject to the changes but can influence the change. For example, in a recent study, Fritz et al. (2023) show that Greta Thunberg's activism and the Fridays for Future movement positively influenced the environmental concern and behaviour of Swiss citizens. Djinlev and Pearce (2024, in this issue), report how bottom-up initiatives helped to raise citizen's awareness about the downsides of hydropower. This increased awareness and pressure from civil society stopped the construction of hydropower plants in two natural parks in North Macedonia. Marquardt and Delina (2019) report how bottom-up citizen activism can shape alternative energy systems. Similarly, the 6th IPCC assessment report indicates that "bottom-up public concern" can speed up the energy transition (IPCC 2022, p. 256).

Individuals and communities can influence the discourse and change the narrative and prevalent norms, which also impacts the existing structures (Brisbois 2019). The role of the consumer is limited by one's ability to participate in the market. The role of the citizen is limited by one's access to the political sphere. Power imbalances might also influence who is able to influence the narrative (Wagner 2018). Laakso et al. (2023a, in this issue) discuss the frames media uses to describe the roles of individuals. They show how media depictions cover a wide range of households as agents of change or victims of transition during an energy crisis brought about by the Russian war in Ukraine. Tracing the contours of this discourse in Finnish media in 2021–2022 shows how these frames and media representations can influence narratives and norms.

The current energy transition offers various pathways that have different outcomes in terms of structure and (political) power distribution. With changing ownership structures, the energy transition is not only about technologies and market mechanisms but also about political questions (Thombs 2019). By reducing the energy transition to technology and market mechanisms, renewed roles of citizens such as the prosumer might not lead to an actual change in terms of democratisation and consumer empowerment (Antonio 2015; Ritzer 2015). However, as highlighted by Bauwens et al. (2022) and Thombs (2019), research and policy actors have tended to focus on market and technology aspects, thus limiting individuals to their role as consumers (Dunphy and Lennon 2022).

Overlap of roles

There is considerable scope for overlapping roles of individuals in energy transitions. Thus, this section serves to highlight that the distinction between the different roles, provided above, only serves an analytical purpose.

Furthermore, the overlaps briefly outlined here, only provide some selected examples of how roles overlap and do not exhibit an exhaustive analysis of how different roles overlap.

An example of overlapping roles relates to energy communities, where individuals are also investors. However, greater participation might be granted in such a setup, as individuals with less financial means might also be able to participate, thus broadening the scope for coalitions across lines of social difference. Citizen-based energy systems, where citizens self-organise to produce and sell surplus energy (Green and Newman 2017), could be a form of democratisation. This would then combine political and economic agency in individuals working collectively to become energy market actors while also building social momentum for energy system change. The emergence of such hybrid roles and structures not only affects (political) power dynamics, but also energy demand (Thombs 2019). Thus, the political dimension connects to behavioural and lifestyle aspects discussed above. Moreover, energy utilities themselves have research and development units that perform the role of innovators; hence these incumbents occupy a range of roles increasingly extending to that of intermediaries, a type of actor that is proliferating to organise households into collectives that can structure individual inclusion in energy markets in the form of energy communities (Scharnigg and Sareen 2023). Further role hybridisation of individuals is likely as energy transitions proceed, and such overlaps can be critical enablers of improved understanding and information flows.

Articles in this Special Feature

In this section, all nine contributions to this Special Feature are briefly introduced through a concise summary. As just indicated, there is considerable overlap between different roles of individuals, thus, the contributions are not presented along the role categories introduced above.

(Too) high hopes? How Austrian energy community actors construct their roles in the energy transition

Vogler and Kump (2023) delve deeper into the roles of individuals within energy communities. They report on the results of a qualitative study on energy communities in Austria. At times energy communities are ascribed transformative potential, as they support the use of renewable energy, introduce new business models and institutions, foster agency or act as incubators for innovations. Individuals within energy communities might be portrayed as idealistic, who prioritise common goals over individualistic (monetary) goals. However, Vogler and Kump (2023) scrutinise this assumption. The authors identify four roles within energy communities, grassroots, entrepreneurial, local hero, and techno-centric. These roles are discussed through five angles, social, political, environmental, technological, and economic. The grassroots actor role focuses on environmental goals and has a strong drive to get others engaged. Individuals taking the entrepreneurial role are mostly concerned about economic aspects, such as consumer's willingness to pay. The local hero is strongly connected to the local environment and embodies a protective role. The techno-centric individual is technology savvy and focuses on the technological aspects including the efficiency of initiatives. Vogler and Kump (2023) conclude that only the grassroots and techno-centric roles exhibit the transformational potential ascribed to energy communities. The entrepreneurial and local hero roles are more related to energy community internal affairs.

Empowering citizens for the energy transition: facilitating role change through real-world experiments

As stated above, the energy transition might exclude some individuals with lower income or a lack of assets. The installation of certain technologies, such as solar PVs, might favour those who own a home. Consequently, tenants might be excluded from actively participating in the energy transition. The contribution by Trenks and Bögel (2024) addresses this by studying balcony solar PVs in rental homes in Germany. Using a real-world laboratory setting, they study whether tenants experience a sense of empowerment when becoming prosumers. Trenks and Bögel (2024) combine a spatial with a socio-psychological approach to analyse the role change from consumer to prosumer. The spatial dimension not only encompasses the geographical or physical but also the cultural and normative aspects of space. Coupling these aspects with a socio-psychology lens, allows the authors to study tenants' changing perceptions of space, as well as of meaning, along with changing practices. The real-world lab setting enabled the authors to follow the tenants over a period of twelve months. Data was captured throughout this period using interviews and surveys. They found that tenants gained knowledge about their solar PV installation as well as their energy consumption. This knowledge empowered tenants to shift energy use to make the most of the balcony solar PV. Tenants reported that previous to participating in the experiment they felt left out of the energy transition. Hence, the balcony solar PV allowed them to become active agents in the energy transition. Furthermore, this experience inspired some tenants to become even more active. For example, some started to act as multiplicators telling others about the potential of balcony solar PVs.

Agents of change or victims of transition? Media framings on household roles during the energy crisis

The article by Laakso et al. (2023a) and colleagues addresses the role of the media in mobilising particular depictions of households in the energy transition, and the range of the roles thus depicted, and to varying extents reflected in household practices. The authors examine what roles the main Finnish newspaper Helsingin Sanomat prescribes to households, based on an analysis of 220 articles over a year in 2021–2022, when the Russian war in Ukraine was seen as a disruptive accelerator for European energy transitions. The disruption is characterised as unforeseen and unjust, and the authors argue that this energy crisis—a relatively pronounced concern in Finland—offers a window to nuance the understanding of the agency that households exhibit, towards enabling a fuller role for them in transitions to low-carbon energy. The paper approaches roles as carriers of agency, and locates them at the interface of individuals and society, as a means of establishing a shared reality. Specifically, they probe whether the media frames mobilised to depict household roles in the energy crisis depict them as active changemakers or passive victims, as two ends of the spectrum of agency. They do so by deploying content and frame analysis methods. At the active end, roles transcend energy saving behavioural change to include citizenship and engagement in political debate. The contribution is positioned within a useful overview of the varied roles energy transitions research assigns to households. The analysis spans five frames, spanning five effects, namely economic, environmental, societal, lifestyle, and moral effects.

Memory in energy transitions: individual agency through historical narratives in the energy transition to gas and electricity in the Dutch household

The contribution by ten Berge (2023) also demonstrates the value of a historical perspective to understand the embeddedness of individuals within the energy system. More precisely, the paper enriches sustainability transition research with the insights of memory studies. Memory studies is an academic field studying the use of memory as a tool for remembering the past. A historical case study on the role of housewives in the transition to gas and electricity in Dutch households concludes that individual agency in energy transitions moves beyond choices of use and consumption. The author explored editions of the Monthly Magazine of the Dutch Association for Housewives (NVvH), published between 1913 and 1942. The results reveal a framework that produces a range of historical narratives on household use of gas, electricity, and other energy sources. Based on this exploration, ten Berge (2023) concludes that people create a variety of historical narratives that depict how we will use energy in the future. This future determines how we use energy in the present, which we justify by looking at our past. As such, this historical case study points out that, as a society, we need to be aware that we can learn from the past.

How individuals make sense of their climate impacts in the capitalocene: mixed methods insights from calculating carbon footprints

Tensions between the roles of individuals and the systems they are part of become particularly clear in the article on calculating carbon footprints (Jack et al. 2023). What choices have what impacts? What does it mean to know more about the implications of choices such as purchasing tomatoes with a different origin? Often, we read that people are not well informed about the consequences of their choices. Or they ponder about their actions versus the actions of others (other individuals or other types of actors). Nevertheless, where a classical *homo economicus* argument would expect that more information would lead to more informed behaviour this is more complex when it comes to new information on the carbon footprint of one's lifestyle choices. The results show that the felt need and desire to change are often pushed *to the system needing to change* when it considers individuals with a high footprint to start with. Understanding the dilemmas of providing information on the effects of individual choices may provide people with arguments to resist changing their behaviour. The results call, as rightfully argued, for systemic action in addition to individual actions. The challenge is to find the balance between the two and to bring broader sections of the general public *on board*. Addressing this challenge is critical for speeding up the energy transition.

To charge or not to charge? Using prospect theory to model trade-offs of electric vehicle users

In their paper on electric vehicle users, Pelka and colleagues (2024) reflect on the range of models that can modulate charging incentives and behaviour. They focus centrally on the difference across these models in terms of information, in the form of control that users have over determining their own charging behaviour. This goes to the heart of debates on behavioural change versus—or through—automation, where in recent years, consensus has emerged on the far greater scope automation offers to move towards efficient energy systems. This is primarily due to the relatively small payoff from every isolated instance of behavioural change, compared to the intensive cognitive demand placed by the new practices on users. Those are conditioned with energy practices inculcated under energy systems where

energy flexibility historically played a lesser role at the level of individuals. The authors employ prospect theory to analyse trade-offs between different configurations of charging models, in terms of the balance between relinquishing control as individuals and reducing charging costs based on providing service providers with greater room for manoeuvre. They thus make a strong argument for policymakers and service providers to advance a supply-side push for flexibility based on sharing its gains with users by incentivising greater aggregated control over charging. A question that arises is how and to what extent these users retain bargaining power to not also relinquish control over how much of a share of benefits they receive in terms of lower charging costs.

Social acceptance of district heating: evidence from the Netherlands

Positioned within scholarship on leverage points, Onencan et al. (2024) examine the scope to build support for energy transitions anchored in the Dutch housing cooperation system. They approach social acceptance as a complex matter that extends beyond aspects that relate to a specific technology, and differentiate between acceptance of a technology and a project. Taking up the case of acceptance for district heating above a requisite legal threshold, they dig deeper to also examine the psychological factors that underpin the diverse motivations of households, drawing on a household survey with 95 respondents. They point out that households retain certain concerns despite coming on board the transition, for instance pertaining to uncertainty over future energy price developments. Their analysis shows that simply raising awareness about municipal transition plans does not resonate strongly with households, whereas prioritising interventions that enable households to displace natural gas reliance is in itself quite effective in addressing their lingering doubts. Importantly, the authors emphasise that activities focused on boosting interpersonal trust fare better than those that deal with trust in institutions, which is weak in relation to the energy sector. They emphasise the utility of a leverage points approach for local practitioners and decision-makers—ranging from municipalities to pilot project designers to housing corporations—to orient and implement energy transitions.

Beyond a checklist for acceptance: understanding the dynamic process of community acceptance

Traditionally, policy and research often regard the acceptance of renewable energy technology as a controllable outcome, focused on the opinion of citizens that need to overcome their NIMBY (not in my backyard) feelings. This paper by Kluskens et al. (2024, in this issue—under review), moves away from this outdated perspective. It demonstrates that community acceptance occurs over time and goes beyond citizen acceptance alone; it involves multiple actors, including residents, authorities, and other stakeholders. The authors did an in-depth case study analysis of eight wind and solar projects in the Netherlands. They enriched the analysis with data from 32 interviews with key stakeholders from the selected cases. The findings show that the sum of individual and rather heterogeneous approval responses by a variety of stakeholders can shape the overall acceptance of renewable energy technology implementation. Furthermore, the authors unpack different dimensions of acceptance, allowing them to reveal that even in uncontested projects (i.e. implemented without delay due to opposition), acceptance is ambiguous and includes various responses towards various objects. The paper further demonstrates that roles can influence and interact dynamically with responses and that preferences for roles are heterogeneous. In sum, this paper reveals a very dynamic process of acceptance.

Collective action lessons for the energy transition: learning from social movements of the past

The power of collective action to bring about change is discussed in the contribution by Djinlev and Pearce (2024). They suggest that change happens through the interplay between the collective and individual levels. Specifically, they focus on the connection between collective and individual norms and behaviours as well as power structures. Referring to the concept of tipping points a transition takes place when a social tipping point is reached, which can be facilitated by the interplay between the collective and the individual level. The authors apply a socio-ecology lens to 22 historic transition examples, in which collective action and social movements were key. Through these examples, they identify variables that help to understand the central elements contributing to the transitions. These variables are then applied to two additional cases; social movements against the tobacco industry in the USA and citizen engagement against the construction of two hydropower plants in national parks in North Macedonia. The selection of cases indicates that their analysis is not about the technologies needed for the energy transition but about the social mechanisms underlying change in socio-ecological systems.

Discussion

The discussion of different roles, presented in this editorial, is not exhaustive but serves to put the contributions within this Special Feature into context. Due to the diversity of roles individuals exhibit within the energy transition, the

contributions necessarily provide select insights rather than a comprehensive overview. Nonetheless, this range and basis for reflection helps to achieve a deepened appreciation of this diversity and the need—and scholarly significance—of bringing more of such a focus into energy transitions research.

This Special Feature convenes the nine scholarly articles summarised in "Discussion", which have different foci. Several articles delve into the topic of technology acceptance (Kluskens et al. 2024; Laakso et al. 2023a; Onencan et al. 2024). Other focus areas were information as a tool to influence behaviour (Jack et al. 2023), collective action (Djinlev and Pearce 2024; Vogler and Kump 2023), media framings (Laakso et al. 2023a), and learning from history (Djinlev and Pearce 2024; ten Berge 2023). The articles cover the three clusters of roles (technology adoption, lifestyle choices, and political action) posited and discussed here. Since roles overlap, most contributions cannot be attributed to only one cluster. For example, the contribution by Onencan et al. (2024) provides insights into technology acceptance but also into potential challenges to collective action. The real-world lab study about balcony solar PV installations in Germany (Trenks and Bögel 2024) gives insights into tenants' role as prosumers as well as into citizen empowerment.

As stated above, some energy transition literature indicates that the consumer or technology adopter role of individuals is often overemphasised. Thus, more research is needed that sheds light on other roles of individuals as well as the overlap of these roles. Research on other roles of individuals within the energy transition might help to analyse aspects of (political) power and justice. Shedding light on the overlap of roles might help to understand why interventions that focus only on technology adoption might not deliver the expected results. Technology adoption might need to be understood in tandem with behavioural and lifestyle questions to reduce rebound effects. Or to not exclude individuals from a lower income bracket, individuals should not only be seen as consumers, but actors who have the right to participate in and directly benefit from the energy transition. Thus, individuals are, on the one hand, part of a participatory process to realise some communal or national renewable energy projects. On the other hand, these individuals are also technology adopters (Onencan et al. 2024). However, participation not only revolves around acceptance (Kluskens et al. 2024) but also mobilisation against such projects (Djinlev and Pearce 2024). Furthermore, we might need more understanding of how consumption as a political act can support or hinder the energy transition. Likewise, using a power lens, the inability to take certain roles might also provide insights. Where and why are individuals limited to the consumer role? Where can individuals not take political action and thus not shape the energy transition? Consequently, how can these roles be supported so that individuals become empowered agents within the energy transition irrespective of their socio-economic situation?

It might also matter which analytical frame or lens researchers use. For example, the energy transition is often analysed through a socio-technical lens. However, as the 2024 International Sustainability Transition (IST) conference theme (Sustainability Transitions and Nature) indicates, this perspective might neglect the environment (STRN 2023). Thus, while one can indeed frame technologies within a socio-technical frame, one could also apply a socio-ecological framing as one contribution in this collection does (Djinlev & Pearce 2024). Apart from the social inequalities within the current energy system, it also places a massive burden on the environment, for instance affecting the planetary climate. Thus, individuals are not only part of a socio-technical system, but of a larger, complex natural system. Insights from social ecology, political ecology, and ecological economics can potentially help extend understanding of the roles of individuals within the energy transition. This could provide connections with cases where individuals act as stewards of their environment. Furthermore, a socio-ecological lens also connects to resilience theory and to the notion of (social) tipping points, which are useful frames to understand transitions (Lenton et al. 2023).

It also brooks mention that this Special Feature has limited geographical coverage, tending to focus on European contexts. More thematic research in diverse contexts globally, grounded in plural epistemic traditions, are needed to enrich our understanding of the roles of individuals within heterogeneous energy transitions.

Conclusion

The contributions in this collection showcase considerable variety in how the roles of households and citizens—manifold in themselves—can be addressed in energy transitions research. In convening this collection, our motivation was to deepen understanding of these roles, as well as to advance appreciation of their significance. This Special Feature is testament to the timeliness and generative value of such an endeavour, and a reminder that the task of mapping and taking on board the implications of household agency (and lack thereof) remains a critical and understudied focus area of sustainability transitions. This lacuna, only partially mitigated by this collection, conditions the status and messaging of sustainability science more broadly. What do we as sustainability scientists offer individuals from our research on energy transitions, and how can they play more meaningful roles through particular forms of engagement to

advance just and rapid energy transitions? The contributions offer several sets of wisdom in this regard, and not least, illustrate numerous methodological approaches that can be productively deployed to make further advances.

In sum, there is a tremendous need for, and opportunity to make contributions to a broader, more public form of energy transitions that centre on individuals and/or on their agency in enabling societal transformation towards low-carbon energy systems. This plays a dual role, advancing climate mitigation on the one hand, and stoking greater political mobilisation and public discourse to enhance the legitimacy and urgency of just energy transitions on the other hand. In this latter sense, the role of individuals is crucial beyond the carbon emissions they emit, directly and indirectly. Their engagement can expand public appetite and demand for particular desirable forms of transition that in turn lead to greater momentum for energy transitions as such, also in less public-facing domains like industrial decarbonisation where individuals have a more limited role to play.

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