Energy Research & Social Science 103 (2023) 103213

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Review

A fairway to fairness: Toward a richer conceptualization of fairness perceptions for just energy transitions

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ARTICLE INFO

Keywords:
Fairness perceptions
Distributive fairness
Procedural fairness
Recognitive fairness
Environmental justice
Behavioral game theory

ABSTRACT

Current energy justice literature has developed a strong empirical approach to describe how justice plays a role in energy transitions. We argue that the individual-level perception measures are insufficiently developed within this field, while they are vital for a successful just energy transition. Reviewing studies on how people (citizens, users or consumers) perceive fairness in the context of the energy transition, we first investigate how fairness perceptions are currently studied within energy social science. Subsequently, we look into social and environmental justice research and interdependent decision-experiments, to map potential extensions of fairness conceptualizations and measures. Following the triumvirate model of energy justice – distinguishing distributive, procedural, and recognitive justice – we found that only recently studies also contained recognition justice aspects, while the majority of energy social science studies focuses on either distributive or procedural aspects. Extending these insights, we argue that environmental justice research provides a potential way of specifying groups to be recognized in the energy transition (i.e., future generations, non-human species, humans worldwide). Moreover, we propose that interactional justice could be an additional tenet of citizen's fairness perceptions to consider. Importantly, for a successful global energy transition, in-depth insight into the principles underlying people's justice judgments is necessary. Social justice theorizing and interdependent decision-experiments offer concrete ways of tapping into these principles. Interdependent decision-experiments in particular pose a way of measuring fairness tendencies that could be applied to the specific context of the energy transition and be expanded beyond the current research focus measuring distributive justice perceptions.

1. Introduction

The depletion of fossil energy resources, pollution from energy waste, and increasing pressures due to the emerging consequences of changing climate and global warming all make a global sustainable energy transition crucial and urgent [1,2]. In addition to technological innovations, societal acceptance of new energy technologies and energy policies (e.g. wind parks, carbon capture and storage), as well as the acceptance of additional costs and burdens (e.g., the costs and effort needed for installing solar panels on one's roof) and a willingness to change one's energy behaviors (e.g., reducing energy consumption and adopting new energy behaviors) are vital to successfully transition to a more sustainable global energy system [3,4]. Such acceptance and willingness to change cannot be realized without taking into account fairness and justice considerations. Only if people believe that the changes required for the transition are fair, will they be more willing to adopt sustainable energy behaviors, refrain from non-sustainable behaviors, and accept some personal and societal costs and burdens [5,7]. Importantly, failing to take into consideration these citizens' fairness perceptions can result in disengagement from the transition as well as active resistance and protest against it [8]. More broadly, it can result in distrust in the political system and contribute to growing questions around the legitimacy of power in general [9]. In addition, some scholars have argued that for the transition to a more sustainable global

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https://doi.org/10.1016/j.erss.2023.103213
Received 22 February 2023; Received in revised form 9 June 2023; Accepted 14 July 2023
Available online 9 August 2023

energy system, more democratic control is necessary [10,11]. As such, individuals' fairness perceptions and the ways these could be taken into account are vital and therefore warrant further attention.

Research into fairness perceptions is currently scattered across various scientific disciplines (e.g., energy justice, environmental justice, social justice, behavioral economics, risk research, science communication). Conceptualizations of fairness and ways to measure perceived fairness diverge both across and within these disciplines. This hampers understanding and comparison of empirical evidence from different research traditions. In the current paper, we set out to (1) provide an overview of existing conceptualizations of fairness based on theorizing on energy justice (notably the three tenet approach) and social science research in the energy context (which we refer to as energy social science in short) that has measured fairness or reactions to (un)fairness in energy transitions, and (2) complement these with insights and reflections from social and environmental justice research and interdependent decision experiments using a behavioral game theory approach that can extend and enrich energy transitions theorizing and research into fairness perceptions [12]. We selected the fields of social and environmental justice research, because they are most closely related to fairness studies beyond the energy context. Interdependent decision experiments were included, because they provide insight into fairness perceptions in actual interactions and allow for subtle distinctions in abstract behavioral conditions related to fairness to study causal consequences of these conditions. As such, these studies provide a potential way of measuring fairness perceptions similar to how they occur in real life (i.e., in interactions within a social system). A consideration of a broader set of approaches to fairness may inspire extant research on perceptions of fairness in the global sustainable energy transition in important ways. As such, we aim to create constructive synergies between different fields of study to better understand fairness perceptions in the energy transition. We hope to provide useful recommendations for future research on fairness in the energy transition and the role that knowledge about fairness perceptions can play in smoothening the sustainable energy transition.

We start by shortly introducing the growing field of energy justice research. We then present an overview of contributions of social science studies in the energy domain to gain an understanding into what is currently known about how people in the role of citizens, users or consumers perceive fairness and make fairness-related decisions related to the energy transition. Subsequently, we outline important insights from fields that study justice and fairness, partially in relation to climate change in particular, and that have remained largely separate up until now (i.e., social and environmental justice research and interdependent decision experiments). We discuss how these can be valuable for research and theorizing on perceptions of fairness in the global sustainable energy transition.

Before we begin, we note that justice and fairness are often used interchangeably in the energy justice and social sciences literature. Yet, the two concepts differ in important ways, with fairness being the more abstract notion and justice constituting the system of rules implemented by social institutions through which fairness can be attained [13]. As we believe this distinction to be important, in the current paper, we use the two terms in this manner, at times diverging from the exact terminology used in the specific fields.

2. Energy justice research

Reflecting the relevance of fairness considerations for a successful energy transition, the emerging research field of energy justice is quickly expanding [14–17]. Within energy justice research, two main approaches to achieve a fair energy transition are posited. First, McCauley and colleagues [16] propose three central tenets (the 'triumvirate of tenets') to energy justice: distributive justice, procedural justice, and recognitive justice. *Distributive justice* concerns the just allocation of environmental and other burdens and benefits across all members of society. *Procedural justice* concerns the just process of agreeing upon these distributions (e.g., transparency, voice, power-free dialogue). *Recognitive justice* concerns the just representation of all involved, with a special emphasis on the least powerful (e.g., inclusion, diversity, rights of the least well-off). Second, building on these three tenets, Sovacool and colleagues [18] present an energy-justice decision-making framework that operationalizes energy justice into eight principles aimed at informing energy practice: availability, affordability, due process, transparency and accountability, sustainability, intra-generational equity, inter-generational equity, and responsibility.

The energy justice community has been prolific in applying the three tenets approach in the decade following the introduction of the theory. Several articles have conceptually elaborated the three tenets theory further [19–25]. The majority of studies uses (one of) the following methods to establish what a just energy transition would amount to: studying policy documents or secondary documents on policy developments [26–32]; or performing in-depth interviewing with a selection of key actors in the field [30,31,33–36].

These inquiries all look at energy justice from an overarching perspective. They rely on what specific, often well-informed, key actors consider relevant for a just energy transition, but they do not make further inquiries into what most individuals consider just and fair and what they give as reasons why they think they do. Put differently, what these studies largely do not focus on, is what people involved in or expected to engage in the energy transition at large (i.e., the end-users or citizens) perceive as fair and unfair and why. To our knowledge, two papers within the field of energy justice form an exception. Rasch and Köhne [37] performed an engaged ethnographic case study to answer why people voice certain opinions. And Velasco-Herrejon and Bauwens [38] performed a qualitative-quantitative-qualitative approach, including inquiring about diverse community perceptions on capabilities with a questionnaire. This latter article, to our knowledge, is the only one using the three tenets approach of energy justice to map how larger groups of individuals experience fairness.

In the current paper, we provide an overview of a broader realm of empirical studies into fairness and justice to extend these measurements of individual-level fairness perceptions to inspire the further study of people's perceptions of fairness in the energy transition. In doing so, we first scope existing social science research within the energy context that has measured fairness perceptions or reactions toward perceived (un) fairness, after which we discuss social and environmental justice research and game theory studies respectively to provide further insight into how future fairness perceptions studies might be extended and enriched. Even though the majority of studies presented here oftentimes uses a specific conceptualization of justice, primarily focusing on only one dimension of justice, and does not explicitly apply the three tenets approach, we will apply this approach throughout the paper to structure our discussion such that we present our findings related to distributive, procedural, and recognitive justice respectively.

3. Empirical work in energy social science

Within energy social science, some empirical studies have shed light on individual-level fairness perceptions regarding the energy transition [4,39,40]. Most of these studies present participants with a (hypothetical) potential scenario of a sustainable energy project (e.g., a particular division of burdens and benefits or a project with vs. without the opportunity to voice one's opinion) and prompt participants about their fairness judgments for and the acceptability of this scenario either in an experiment (e.g., [41–45]) or as part of a survey (e.g., [5,46–48]). As we outline below, the majority of these empirical studies focuses on one aspect of the three tenets in particular; distributive, procedural, or (much less often) recognitive justice. In addition, some studies focus on the effects of general fairness perceptions (e.g., asking how fair people find something in general) or combined fairness perceptions (e.g., including both distributive and procedural justice aspects) for the

acceptance of sustainable energy projects [46,48].

3.1. Distributive fairness within energy social science

Many studies in the field of energy social science focus on distributive justice, investigating different ways of balancing economic and other (e.g., time, effort, comfort, access) benefits, burdens, and risks (i.e., distributive justice). Empirical studies on distributive fairness showed that the impact of a sustainable energy project is a crucial driving factor shaping emotions, acceptance, and opposition to these projects [5,41,49–51]. When energy projects impact citizens directly (e.g., in on-shore as opposed to off-shore wind turbine projects), these distributive fairness considerations become more important for acceptability of these projects [52].

With regard to burdens and benefits in particular, several review studies showed that a fair distribution of benefits and burdens will increase acceptability of sustainable energy projects [4,39,40]. Energy projects oftentimes show a disbalance between burdens incurred locally, and benefits distributed non-locally [53]. Studies show that people prefer an equal distribution of regional benefits (e.g., the introduction of a municipal fund to finance environmental protection measures or building restorations as opposed to only compensating the farmers whose land is used for the wind turbine project) and dislike it when some groups in society are disproportionally burdened by the energy transition and when big companies earn a lot of money at the expense of citizens [45,51,54]. In projects that are considered urgent, people sometimes accept a trade-off between economic and political needs at the expense of social and environmental impacts. However, at the same time projects in which urgency is stressed raise suspicion of not considering all options available carefully enough, which can negatively impact acceptability [54].

In addition to the direct effects of incurred benefits, burdens, and risks on fairness perceptions and the acceptance of sustainable energy projects, studies on distributive justice are oftentimes also about perceived fairness of different compensation schemes to reimburse distributive imbalances [44,53,55,56]. To account for imbalances in burdens and risks, various types of compensations can be offered to increase acceptance of sustainable energy projects (e.g., monetary or in-kind compensation). Monetary compensations in particular, however, can be perceived as a bribe by people affected and could, as such, elicit a back-lash effect, negatively influencing acceptance of the project [53]. Yet, some studies also show that even if this monetary compensation is recognized as a bribe, the overall benefits can be seen as more important [55]. Overall, in-kind compensation seems to work better than monetary compensation [53]. One potential reason for this might be that an in-kind compensation scheme, when tailored well, might address a broader set of fairness concerns, including distributive justice, procedural justice aspects such as accurate information and transparency, and recognitive justice aspects [56].

3.2. Procedural fairness within energy social science

In addition to concerns about the distribution of benefits, burdens, and risks, the degree to which people are included in the decision-making process is also deemed vital for fairness perceptions [47,57]. Procedural justice centers around this inclusion of citizens in the decision-making process, which can take different forms, ranging from passive to active involvement. Passive aspects of procedural justice, such as the need for people to be provided with information, and for the decision-making process to be transparent, can be considered necessary preconditions for perceiving the energy transition procedures as fair [57]. For instance, projects on carbon capture storage, high-voltage powerlines and wind power showed that a lack of openness and of timely, relevant, and trustworthy information are indeed problems that citizens living nearby these projects experience [5,51,58].

Furthermore, additional research suggests that more active involvement further increases the likelihood of people perceiving the transition as fair: people need to be allowed to participate and have a voice [43,57,59,60]. Several case studies on renewable energy projects have concluded that technocratic top-down decision-making processes inhibit public acceptability and might even result in opposition, while collaborative approaches taking community concerns into account enhance acceptability [52,61–64]. Not only simply allowing all stakeholders to voice their opinion, but also taking these opinions serious and taking them into account in the decision-making process is needed to warrant high procedural fairness perceptions [5,58,65]. People also want to be engaged in the early stages of the process, before crucial decisions have been made [66,67].

Recent studies, however, nuance previous findings with regard to active participation. These studies show that at times people can also be overwhelmed by too much information, especially when the information provided is uncertain [67], and that consultation with experts panels or panels consisting of experts and citizens might be preferred over active personal participation [68]. In addition, people value active participation more when major decisions can be influenced as opposed to minor ones [42]. Furthermore, people prefer to participate in local decision-making as opposed to more higher-level (e.g., national, transnational) decision-making [69]. This might be explained by the fact that local energy projects may feel more relevant and as more likely to directly impact people than more abstract energy policies. Moreover, local sustainable energy projects are likely more concrete and will therefore be perceived as more comprehensible than abstract, high-level energy policies.

In addition to studies specifically focusing on either procedural or distributive fairness, some studies have considered the two in tandem [5,45,51,70]. While one study stressed the importance of distributive fairness [45], others emphasized the effects of procedural fairness aspects or the combined and intricately linked effects of both procedural and distributive fairness concerns [5,51,70]. For instance, for the acceptance of wind energy projects in Australia, outcome favorability seemed to shape acceptance of the project for those people directly affected by it (i.e., those who stand to gain or lose) [51,52], but outcome equality and fairness of the process seemed more relevant for others in the community for deciding on the desirability of the project [5].

A few studies looked at multiple fairness considerations in the context of nuclear energy [71,72]. While it can be debated whether it is a sustainable technology or not, at least it is a low carbon technology. One study looked at both procedural and distributive fairness and found that both predict acceptance of decision to rebuild nuclear power plants, with distributive fairness having a much stronger effect than procedural fairness [72]. Another study considered not only distributive and procedural fairness, but also interpersonal fairness, operationalized as "respect (…) that decision makers in the process of public hearings about issues such as nuclear power have for the views of the public" and "trustworthiness of decisionmakers in the process of public hearings about issues such as nuclear power" (p.266) [71]. The study found that all three types of fairness were predictive of satisfaction with and legitimacy of the public hearing process for deciding to increase the number of nuclear power plants, but only distributive fairness significantly predicted acceptance of expanding nuclear power plants. It thus appears that in the nuclear context, particularly distributive fairness is important for acceptance.

3.3. Recognitive fairness within energy social science

Very recently, social science studies in the energy domain have also brought recognition issues to the fore, relating to concerns that citizens have about disadvantaged groups [70,73–75]. For example, studies have shown that people felt that those with a low income should pay less for their energy than those with high incomes [70]. People also expressed concerns for particular groups of people at risk of being disadvantaged by energy projects. For example, study participants stated that the

decision-making regarding the siting of a spent nuclear fuel repository did not give enough voice to the disadvantaged in society [75], or were concerned that the needs of economically disadvantaged groups (e.g., elderly, disabled, shift workers) would go unrecognized by proposals for domestic and community scale flexibility and that rich people would be better off selling their home-produced electricity, while poor people would be worse off [74].

3.4. Conclusions on literature from energy social science

Within energy justice research, distributive justice, procedural justice, and recognition justice are considered the three central tenets for achieving a just energy transition. We find that social science studies in the energy domain mostly concern people's perceptions of distributive and procedural fairness and show that equal or proportional distributions of costs, risks, burdens, and benefits, as well as passive and active involvement in the decision-making process contribute to perceptions of the energy transition as fair. The majority of these studies probe people's fairness judgments after presenting them with a potential scenario of a sustainable energy project. Recognitive fairness has recently started to attract attention in in social science studies in the energy domain, and has not yet been frequently studied. Emerging research shows that people might be concerned in particular with groups at risk of falling behind in the energy transition. While the studies reviewed here already provide many valuable insights, related fields of study (i.e., social and environmental justice research and interdependent decision experiments) can provide additional insights that can extend and enrich current conceptualizations and measurements of fairness perceptions in the energy transition. In the following we will look at research conducted within these fields, specifically focusing on they could add to energy social science with regard to measuring individual level fairness perceptions.

4. Insights from social and environmental justice research

The findings from energy social science on distributive and procedural fairness align well with the classical distinction that social justice research draws between distributive justice and procedural justice [76]. Yet, more fine-grained distinctions within and beyond distributive and procedural justice are also made in the social and environmental justice literature, which we will outline below.

Whereas most classical social justice theorizing has focused on questions regarding the fair allocation of burdens and benefits (i.e., distributive justice) [77,78], in the 1980s and 1990s, the study of procedural justice gained significant ground as well [79–81]. Empirical studies have shown that an unfair procedure negatively impact people's fairness judgments and their satisfaction with the outcome, even when this outcome is in their own advantage [82]. Research has also shown that at times, procedural fairness is deemed even more important for people's satisfaction with the outcome, their trust in authorities, and the legitimacy of the system more generally than the outcome itself [83]. This is likely particularly important when people need to deal with circumstances for which they have to incur some burden (e.g., time, money, effort), such as sustainability transitions.

More recently, recognitive justice (also termed justice as recognition) was introduced in the field of social justice research. It was originally coined as a countermovement within sociology against the focus on mainly distributive justice in classical justice research [84,85]. Recognitive justice is focused on the degree to which individuals and groups are fully recognized and respected and on addressing unfair status and power differences between societal groups [86]. Within energy justice, the term seems to be used more narrowly, focusing on the fair representation of all relevant stakeholders, and vulnerable groups in particular. This more closely aligns with theoretical ideas around the scope of justice, as studied empirically in environmental justice research [87].

4.1. Distributive fairness in social and environmental justice research

Within distributive justice, different justice principles have been distinguished [88,89]. Oftentimes a distinction is made between proportionality (i.e., distributing outcomes based on input), equality (i.e., distributing outcomes equally) and need (i.e., distributing the largest outcome to those who need it most). With regard to these distributive justice principles, scholars have argued that the criterion used differs across situations [88,90] and between individuals [90–92]. For example, some people will generally be more inclined to opt for proportional outcomes, whereas others more often choose an equal outcome, when given a choice. Within environmental justice research, empirical studies have found that anti-environmentalists oftentimes use the criterion of proportionality, whereas pro-environmentalists more often use equality or need as distributive justice criteria (oftentimes in combination with an ecological scope of justice) [93–95]. This would likely also apply to the sustainable *energy* transition, where people using equality or need criteria might more likely accept additional burdens (e.g., extra effort, time, costs) to make a sustainable energy transition possible. These ideas resonate with a wealth of studies showing that self-transcending (i.e., biospheric and altruistic) values, as opposed to self-enhancing (i.e., egoistical) values are associated with higher acceptance of sustainable energy systems [96,97]. In particular, equality and need principles more closely align with these self-transcending values.

We posit that the distinction between the different distributive principles in fairness perceptions is highly relevant for energy research, too, and should therefore be addressed explicitly. Yet, as the above shows, to date quite some studies both within and outside of energy research have focused on measuring how fair people find a certain distribution of outcomes and not on why this is the case. In other words, in addition to fairness judgments (i.e., to what extent a certain outcome is deemed fair or unfair), fairness perception measures should also encompass an assessment of the principles underlying these judgments and whether these are oriented more toward proportionality, equality or need principles. Qualitative studies on fairness in the energy transition already provide some insight into the underlying reasons people have for judging specific outcomes as fair or unfair. While some of these reasons echo proportionality principles, like when people mention the unfairness of energy companies earning money at the expense of citizens [54] or the unfairness of local citizens being insufficiently compensated for negative outcomes [5,51], others indeed relate more to equality or need principles, such as when it is mentioned that insufficient consideration is given to the wellbeing of other species and future generations [54] or to disadvantaged groups in society (low-income households, elderly, and people with medical issues) [70,73,74]. Explicitly including measures of distributive justice principles in social science energy research could deepen our insights into the underlying reasons on which fairness judgments are based and create a more complete picture of fairness perceptions related to the sustainable energy transition.

How people evaluate and respond to distributions of, mostly financial, outcomes is also studied in experimental social justice research. These studies seem to suggest that people prefer proportionality as a distribution principle for positive financial outcomes, but equality for negative financial outcomes [98–100]. In the energy transition, not only the distribution of financial outcomes, but also of other outcomes such as well-being, safety, living conditions, hassle, and nuisance are important to consider. People may perhaps prefer different justice principles when judging the fairness of the distribution of these negative outcomes of the energy transition. A first study on this topic showed the relevance of equality as a principle for the distribution of risk and nuisance in the energy transition [41]. As such, the sustainable energy transition also provides ways of extending current social justice research.

4.2. Procedural justice in social and environmental justice research

Whereas most social science research in the energy domain on procedural justice seems focused on voice and the provision of information as procedural aspects to be considered, other aspects have been distinguished in procedural justice research, such as transparency, independence, and ethicality [101]. Moreover, within organizational psychology, oftentimes a distinction is made between formal rules and procedures on the one hand and the way in which people are treated on the other [102]. This latter form of justice is coined interactional justice. Interactional justice can subsequently be subdivided in interpersonal and informational justice, with the former reflecting the respectful treatment in conversations and the latter reflecting transparency and adequacy of information provided. Statistical analyses also support the independence of distributive, procedural, interpersonal and informational justice [103,104]. These treatment-related factors, that are oftentimes not formalized in procedures, can contribute greatly to the support base for new policies and the willingness to change behavior [104,105]. This may be particularly important when some additional burden is involved, which is oftentimes the case in the energy transition.

4.3. Recognitive justice in social and environmental justice research

The question of which people and groups should be considered in judging the fairness of situations or circumstances (e.g., policies, current state-of-affairs, forecasts) has been studied in research and theorizing on the scope of justice [106,107]. Specifically, in theorizing on the scope of justice [87] it is argued that while distributive justice is focused on the 'what' of justice and procedural justice concerns the 'how' of justice, the 'who' of justice should also be taken into account, considering the groups people include and exclude from justice considerations. In the sustainable energy transition, groups that are not traditionally included in the scope of justice have to be considered. Based on environmental justice research, the scope of justice can be extended in three directions [76,108,109]. First, global justice concerns encompass justice judgments taking into account all human beings around the world, with a special focus on economically disadvantaged groups and/or groups that have been unfairly burdened with environmental risks. This extension of the scope of justice seems to most closely align with how recognitive justice is operationalized in energy justice research and theorizing, oftentimes focusing on what is fair for the Global South versus the Global North. Second, intergenerational justice concerns take into account the responsibilities we have toward current young and future generations. Finally, ecological justice concerns extend the scope of justice toward an inclusion of nature and non-human species.

In studies on sustainable behavior intentions, intergenerational justice concerns were found to increase people's anger about environmental damage, and this in turn somewhat increased people's sustainable behavior intentions (e.g., protecting biodiversity; buying products from local farmers) [110]. In contrast, adopting an ecological scope of justice increased a sense of responsibility, which had a stronger positive effect on people's sustainable behavior intentions. Of the three environmental justice scopes, global justice concerns affected intentions for sustainable behavior the least. Nevertheless, subsequent studies focused specifically on making salient a global scope of justice. Such studies showed that activating a global human identity positively influenced sustainable behaviors and intentions, and that this relationship was mediated by global justice concerns [110–112].

Taken together, while studies are only starting to systematically investigate environmental justice concerns explicitly, they do provide a concrete possible construal of the groups that can be recognized in the sustainable energy transition and that extend beyond the traditional groups that are included in the scope of justice. These new groups should be incorporated in studies focusing on the sustainable energy transition. In particular, including future generations, nature and non-human species, and the global population as important groups to be considered, will help conceptualize people's fairness perceptions. Explicitly probing these extensions of the scope of justice may help understand under which conditions acceptance of, resistance toward, and participation in the global sustainable energy transition will occur.

4.4. Conclusions on literature from the social and environmental justice research

In sum, social science studies in the energy domain focusing on fairness perceptions can be extended in a number of ways based on insights from social and environmental justice research. First, distributive justice principles (i.e., proportionality, equality, and need) can be studied explicitly to help understand not only what people find just and unjust, but also why this might be the case based on individual's distributive fairness principles. Second, including procedural justice aspects beyond voice and information provision (i.e., active and passive participation), such as interactional justice perceptions and the ethicality of the decision-making process may provide more fine-grained insight into procedural fairness considerations people have regarding energy projects. Third, extensions of the scope of justice to encompass humans globally, generations to come and non-human species and nature can provide a base for increasing individuals' acceptance of energy projects.

Vice versa, energy social science, where the scope of justice and justice as recognition are studied to some degree, also provides unique opportunities to extend social justice research, in which to date these forms of justice have received relatively little attention. Moreover, whereas most distributive justice research to date has focused on the allocation of burdens and benefits, sustainable energy projects also require consideration of the allocation of risks, nuisance, and uncertainties, allowing an innovative perspective on distributive justice research as well.

5. Insights from interdependent decision experiments

The sustainable energy transition can be framed as a public goods or social dilemma [113–115], making insights based on game theory highly relevant. Social dilemmas are situations in which individuals are better off if they do not act cooperatively, but everybody is better off if everyone cooperates compared to the situation in which no one cooperates [116,117]. Importantly, these social dilemmas provide the opportunity to study people's fairness considerations in interaction with others, thereby more closely resembling the social system within which energy transitions take place. Moreover, the experiments allow for studying subtle comparisons of different conditions related to fairness and their causal relations with perceptions and behavior.

Public goods dilemmas are a specific type of social dilemma, in which the use of a certain public good (e.g., an open pasture, our oceans) can be used freely by all. However, intensive use of the public good will exhaust it. Consequently, it pays off on an individual level to use as much of the public good as possible, but on the collective level the public good needs to be conserved and not overused. The energy transition can be considered a prototypical example of such a dilemma; the transition to more sustainable energy systems is urgent and crucial to be able to preserve the world for future generations, but for everyone individually the costs, burdens and risks that have to be incurred right now do often not outweigh the potential benefits of adopting sustainable energy systems, especially if only a few others join in on these efforts.

Behavioral economics, social psychology, and analytical sociology have researched fairness concerns of people in several types of these social dilemmas. These studies provide important insights in and examples of interdependent behavior in social dilemmas and, as such, are valuable for research and theorizing on perceptions of fairness in the global sustainable energy transition. Below, we summarize behavior in specific games that can be considered direct measures of individual perceptions of fairness about the outcomes of a game or the procedure of

how a certain game is organized. Most of the work done in this field of study reveals information on distributive fairness perceptions, although some studies have also incorporated elements of procedural fairness. We could not identify experiments that explicitly address recognitive fairness.

5.1. Distributive fairness in interdependent decision experiments

To better understand how people weigh contributions and outcomes in terms of fairness, fairness equilibrium models have been developed within economics. These models explain how behavior can be understood game-theoretically if we assume that people also to some extent value the outcomes for others [118–120]. It is generally assumed that people consider equal outcomes to be fair, but it becomes more complicated when these equal outcomes come at a cost. Empirical studies have shown that the extent to which people value equality depends on circumstances, such as how convinced are they that someone else cares about them or would be fair in return in the future [121] or whether there are differences in efforts, benefits or contributions for people in an interaction [122,123]. People may agree that everyone has to contribute to a public good, but how much someone is willing to contribute depends on what (they think) others contribute, how costly it is for a specific person to contribute and how much it takes to earn back the investments. As such, the choices people make in these games can be considered a potential way of measuring the distributive fairness perceptions people hold (e.g., focused on equality or proportionality).

A first example of a game in which the choices people make reveals information on fairness concerns is the dictator game [124]. This is a simple game in which one person can share a certain outcome between themselves and an (oftentimes anonymous) receiver, without the choice of the amount having any consequences in the game. People on average give around 30 % to the other. This shows that people are not completely selfish even if being selfish has no negative consequences. Moreover, a considerable portion of people give the minimal amount set by the game (which varies between studies), but the second most often chosen option is the 50–50 split [124], showing that many participants in these games consider equality to be the preferred outcome.

The ultimatum game adds an interesting twist to this game by allowing the receiver in the game to refuse the offer, which results in a null outcome for both persons [125]. Clearly, there are more splits that are closer to 50/50 proposed in the ultimatum game than in the dictator game. Moreover, 70/30 splits or worse are often rejected by the receiver in this way punishing the proposer who offers an unfair split even though this receiver then also does not get anything. These results signal that many people find 70/30 or more unequal divisions unacceptable and are willing to forsake benefits to avoid the unequal outcome and punish unfair behavior. These findings support the idea that (highly) unequal divisions are considered unfair and that people are motivated to avoid them. Hence, these games provide insight into how willing people are to punish unfair behavior and sacrifice own resources to do so (see, e.g., Camerer [12] on altruistic punishment in the ultimatum game or Fehr and Gächter [126] on altruistic punishment in public goods games). Both insights are relevant for the energy transition, because they signal that if people think they need to contribute much more than others to the transition, they will be less likely to do so and that they might be willing to stand up toward people they think do not contribute their fair share.

Based on these types of two-person bargaining situations, several scholars have developed systematic measures of social value orientation to study division rules that people apply. These measures clearly show that people dispositionally differ in how selfish and how willing they are to contribute to the welfare of others. These measures often use so-called decomposed games resembling series of dictator games in which someone has to choose between two possible divisions of money [127] or can in a more continuous way assign values to themselves and someone else [128]. Based on these measures, people can be classified as either pro-social (cooperative) or as pro-self (individualistic or competitive) [127,129]. Studies using these measures show that around 50 % of people can be categorized as cooperative, implying that they not only value their own outcome but also outcomes for others. They mostly choose divisions in which they themselves and the other person get similar amounts of money. Furthermore, more than 40 % of the people are shown to be individualistic, implying that they mainly value their own outcome. They choose divisions that optimize their own outcome, without considering what others are getting. Finally, a small percentage of people is competitive, implying that they mainly value how much they get more in comparison to the other person. As expected, it has been shown that people with more cooperative social value orientations are also more cooperative in social dilemma situations such as prisoner's dilemmas and public goods games [130]. Such inferences make it plausible that these measures are also predictive for the extent to which people are willing to invest in the energy transition or other types of sustainable behavior realizing that they do not only benefit themselves, but others might benefit as well. Van Vugt and colleagues [131], for example, show a direct relation between pro-social value orientations and willingness to take public transport.

To illustrate more directly how these abstract games can help us understand people's behavior in the energy transition and their willingness to contribute to this real-life social dilemma voluntarily, especially with respect to distributive fairness, we can zoom in on public goods games and the behavioral dynamics of people who play such a game repeatedly. The general pattern is that when people play public goods games repeatedly, the overall contribution they put in decreases over time [126]. The reason is that people who contribute more than average tend to reduce their contributions, while the ones who contribute less remain less collaborative and do not increase contributions over time. Apparently, the high contributors find the unequal contributions unfair over time and try to move to an outcome they find fairer themselves.

5.2. Procedural fairness in interdependent decision experiments

A public goods game can be considered a rather direct simulation of the sustainable energy transition when it does not only focus on which distributions of benefits people prefer, but also includes procedural elements. Fehr and Gächter [126] show that the problem of reduced contributions can often be overcome by allowing people to punish (or reward) others if they find that they do not (or do) contribute appropriately, which could be considered a procedural element. Being able to influence the payoff of another player in a public good game through punishment or rewarding them through decreasing or increasing their payoff can be effective in making a public good game feel fairer and signals the discontent with an unfair outcome. Mostly the high contributors punish the low contributors which leads to more adaptation of the ones who contribute less and often leads to more sustained cooperation (see Balliet and colleagues [132] for a meta-analysis). In the sustainable energy transition, one could imagine that high investments can be rewarded, and the lack of investments can be punished, e.g., by giving discounts for people who are able to reduce energy consumption and ask higher prices for people not willing to shift to green energy sources.

This sounds straightforward certainly if everyone has similar amounts of resources and similar benefits from the public good. The situation becomes more complicated if initial resources (and/or benefits) differ between people, which is often the case when considering contributions to the energy transition (e.g., in relation to socio-economic position). To illustrate, on the global scale, the Global North has the means to promote the energy transition, but still largely fails to do so, while having contributed more to the problems of climate change than the Global South, which in most cases will suffer more from the consequences of climate change. In public goods games with differing initial positions, people can be divided into two groups based on their responses in the game; those who still believe equal *contributions* are

appropriate (e.g., everyone has to reduce their energy use to the same degree) and those who feel that equal *investments* are more appropriate (e.g., those who need to invest more to reduce energy are not required to reduce their energy consumptions as much as those for whom reduction is cheaper (i.e., equitable contributions) [122,123]. Studies implementing such inequalities in people's starting positions in a public goods game have shown that inequality does make collaboration in interdependent games much harder. Additional procedural conditions such as possibilities for communication [133] might help to unite individuals who have different ideas on what different people should contribute. For instance, pledges of fair distribution by the more advantaged at the beginning of such games, have great impact on the success of the group. This way, initial inequalities can be successfully addressed. However, it has also been found that successful distribution of the burdens and handling something like a public threat remain dependent on the willingness to contribute by the more advantaged. It is impossible to address issues, let alone solutions, for all kinds of inequalities on the macro (between countries), meso (between neighborhoods) and the micro-level (between specific individuals) here, and it requires further integration of interdisciplinary viewpoints on these issues (see also Dietz and colleagues [134]).

In a few experimental studies, some participants are brought in a disadvantaged position by the experiment leader, at times even through a procedure that many consider unfair, while others end up in disadvantaged situations due to their own decisions earlier in the experiment [135,136]. Specifically, in a dictator-game like experiment where such procedural differences created unequal outcomes, it turns out that people are more willing to redistribute outcomes if inequalities are created outside the control of the participants in the experiments and without any good reason. Redistribution is much less likely if participants get into a disadvantaged position because they willingly made more risky choices beforehand [135]. This shows that people are more concerned about fairness if the inequalities are created in procedurally non-just ways. In addition, Shor [136] also shows that if participants are treated in a procedural just manner they are willing to distribute resources in a more just way. In this particular experiment, if one participant in a dictator situation explicitly gives the opportunity to split an amount of money among them to another participant, this second participant will share the amount more fairly compared to standard dictator games.

There is only limited research on the effects of procedural fairness directly. A review [137] showed that procedural fairness contributes to social self-identification of people in a group and thus to the extent to which people feel they belong to the group. It also showed extensive evidence that belonging to a group increased cooperation behavior in social dilemma situations. However, only very few studies directly researched the effects of procedures that are considered more or less fair on cooperative behavior (also see De Cremer and colleagues [138,139]). These studies showed that more fair procedures indeed can lead to more cooperation mediated through more belonging to the group.

The few actual interdependent decision experiments investigating if fairer procedures lead to more cooperation, do not give completely consistent results. These experiments suggest that inequalities at the start of a public goods game are especially difficult for cooperation when the participants with the larger endowments feel entitled to these endowments and cooperate less as a consequence of that, although results are slightly different depending on the gender of the participants [140]. Manipulating inequality in cooperation problems by introducing inequalities through merit, ascription, or via a random mechanism induces similar effects; inequality introduced through merit was considered most fair by the participants and by ascription least fair [141]. Moreover, cooperation was indeed reduced in the conditions that are considered less fair: the random and ascription conditions. However, especially men cooperated less in the merit condition when they are in the advantaged position.

5.3. Conclusions on literature from interdependent decision experiments

In sum, research on interdependent behavior and social dilemmas in behavioral economics, sociology, and social psychology has provided extensive insights into how people weigh fairness considerations into the decisions they make. These insights are highly relevant for the global sustainable energy transition as well, as they show how people make these decisions in interactions with others and that these decisions can often be causally related to the conditions in the games. First, behavior in interdependent social dilemma games shows that even in scenarios where it is costly for participants to be fair and there are no consequences of behaving selfishly (as in the dictator game), many people still prefer equality. Moreover, from these experiments, it is possible to deduce general fairness tendencies, or, put differently, these games pose a potential way of measuring distributive justice perceptions (e.g., people's social value orientation). Second, people are willing to pay to punish others they consider to be behaving unfairly, as illustrated by the results of the ultimatum game and altruistic punishment in public goods games, and punishments and rewards can be promising ways to instill continuous cooperation, also in the energy transition. Third, public goods games have shown the importance of communication and pledges of collaboration by the more privileged. This is in particular the case in situations in which the conflict between equal contributions and equal outcomes becomes apparent. For everyone to contribute it seems vital that those with an advantage are willing to reflect their advantage in their contribution. Finally, procedural fairness also seems to increase cooperation, through instilling a sense of belonging. An emphasis on procedural fairness and shared decision-making might be one important element of success of contemporary energy cooperatives.

It is important to note that most of the research discussed here is conducted in abstract game situations under controlled circumstances and can, thus, not straightforwardly be generalized to more applied settings such as the energy transition. While these studies do oftentimes measure behavior with real (financial) consequences, the global sustainable energy transitions provides a promising context for conducting more applied experiments through which such generalizability can be addressed.

6. General conclusions and reflection

Individual-level fairness perceptions have not been studied widely within energy justice research. Most studies within this field to date have focused on how justice considerations should be taken into account in the energy transition according to specific key actors (e.g., policymakers). Yet, citizens' fairness perceptions will be vital for a successful global sustainable energy transition both for instrumental (i.e., increasing acceptance of and engagement with energy transitions) and normative reasons (i.e., from a moral and ethical viewpoint). In this overview, we brought together insights from hitherto largely separate fields of study related to these fairness perceptions to inspire extant research on citizen's perceptions of fairness in the global sustainable energy transition; energy social science, social and environmental justice research, and interdependent decision experiments.

Within energy social science, most studies have focused on the effects of proposing specific distributions of burdens and benefits (e.g., an equal one or a proportional one) or specific procedures (e.g., allowing voice or not) on the acceptability of sustainable energy projects. Less work has been done on consumer behavior specifically, studying, for instance, the willingness to reduce energy consumption. Moreover, most of the studies within energy social science, but also beyond, have focused on fairness judgments in particular. These studies have measured to what degree people consider a certain distributive, procedural, or recognitive justice element fair. They largely do not probe underlying conceptualizations or the principles of justice people use when coming to a fairness judgment or consider most important for these judgments.

Social and environmental justice research offers important insights

into the potential distributive justice principles (i.e., proportionality, equality, or need) and scopes of environmental justice (i.e., global, intergenerational, ecological) that may underlie fairness judgments. Moreover, measures derived from interdependent decision experiments can provide a fruitful way of measuring these distributive justice principles in particular (e.g., social value orientation measures). Including measures that probe these fairness perceptions can deepen our current understanding of citizen's justice judgments and, as such, could help explain why crucial players in the energy transition (i.e., citizens) engage in or resist these sustainable energy transitions.

In addition, social justice research outlines potential additional dimensions of justice that could extend the current triumvirate tenets of energy justice. Notably, interactional justice might be a fourth tenet of justice that plays an important role in forming citizen's justice judgments in particular. Social justice scholars currently differ with regard to the placement of interactional justice as either being a separate dimensions of justice altogether or being part of the broader dimension of procedural justice. Moreover, recognitive justice from a sociological viewpoint already includes interactional elements of justice. Nevertheless, current theorizing on recognitive justice within energy justice focuses largely on who can be considered an important stakeholder, paying special attention to disadvantaged groups and communities. This more limited approach to recognitive justice fails to capture the interactional elements deemed vital in the sociological approach to recognitive justice and could be captured explicitly by including interactional justice as a fourth tenet of citizens' fairness perceptions. Also some of the behavioral patterns in repeated interactions in decision experiments can be related to considerations about interactional fairness.

Besides providing a way of measuring distributive justice principles, interdependent decision experiments have provided a robust way of testing how specific distributive and procedural justice elements causally influence people's willingness to cooperate in these experiments. These findings can be translated into engagement with or resistance to the global sustainable energy transition. For instance, these studies have shown the value of punishments and rewards as well as the need for pledges by the currently advantaged to create support for the transition by all. Moreover, these studies have shown how instilling a sense of belonging can be vital for sustaining cooperation (i.e., acceptance of the energy transition), and how procedural fairness can instill such a sense of belonging.

The global sustainable energy transition also offers ways of extending current theorizing and research within social and environmental justice research as well as in interdependent decision experiments. Not only does the transition provide a fruitful ground for testing some of the theoretical ideas discussed here in a more applied setting (e.g., how specific distributive or procedural justice elements work or whether the threefold typology of distributive justice principles is a complete reflection of the principles people apply), it also allows us to look specifically at risks and uncertainties, not oftentimes considered in distributive justice until now and at empirically studying recognitive (and interactional) justice. As such, studying individual-level fairness perceptions extends the energy justice literature in important ways by creating an in-depth understanding of how citizens perceive a fair energy transition and creates constructive synergies between different fields of research offering opportunities to study these fairness perceptions in novel ways.

Funding

This work was supported by the Fair Energy Transition Center (funded through the alliance TU/e-WUR-UU-UMC Utrecht University, The Netherlands).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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