Just Share It! Designing for Justice in Peer-to-Peer Energy-sharing

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Figure 1: Pictures of the Just Share It! prototype running on a tablet. Left: Landing page with current energy consumption. Center: Forecast for energy production and consumption. Right: Distributing energy excesses between peers.

ABSTRACT

Peer-to-peer (P2P) energy-sharing systems are emerging as infrastructures that let local communities participate in sustainable energy transitions. By forecasting energy production and consumption, energy community members can share energy with their peers to achieve local environmental, economic, and social benefits. Despite hopes that energy community projects will promote justice, P2P energy-sharing and related infrastructures may exacerbate injustices related to energy access, community participation, and recognition of rights. We present Just Share It!, a speculative tablet-based P2P energy-sharing system. This system questions how we might design for energy justice by presenting users with choices for P2P energy-sharing grounded in research on energy community justice. In doing this, we discuss how HCI might design for justice in energy transitions, as well as tensions that may arise.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; *Ubiquitous and mobile computing*; *Interface design prototyping*.

KEYWORDS

P2P energy-sharing, energy communities, energy justice, speculative design

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1 INTRODUCTION

As concerns regarding the sustainability of energy consumption continue, so do attempts to transform our energy systems. One such transformation concerns energy communities, which prioritize *local*, *communal* energy production and consumption that is *independent* from monopolized energy grids [2]. Enabling citizens to participate in local energy communities promises "economic development, the creation of new jobs, cheaper energy, self-sufficiency, community cohesion and energy security" [6, p. 2]. To this end, we see the design and development of digital technologies that support communities in, e.g., shifting their energy demand [13], and comparing households' energy consumption [7]. Such technologies embed promises of *energy justice*, a concept which concerns the importance of fair distributions and just representations in the development, implementation, and enactment of future energy systems [1]. Hence, energy justice emphasizes how community members taking part in energy transitions must experience equal *distribution* of benefits and drawbacks, access to *procedural* decision-making, and *recognition* of rights [8].

Recently, we have seen developments in Peer-to-Peer (P2P) energy-sharing systems. Such systems enable "end-users to cooperate distributively, potentially bypassing the centralized grid system, and share their energy resources" [3, p. 35], mirroring broader energy community goals. P2P energy-sharing uses energy consumption and production forecasting to match community members with energy available for sharing with peers who are in need of energy [3].

Wilkins et al. [19] investigated the values relevant to P2P energy-sharing platforms, showing how such platforms are perceived as providing opportunities for communal participation and engagement towards energy transitions. However, such systems may also create power disparities between energy consumers and energy producers [14], highlighting how P2P energy-sharing may exacerbate injustices. Such notions of justice are also considered more broadly in communal energy projects. The provision of communal energy generation may serve to enact justice in transforming working and living conditions [17], as well as providing communities with the opportunity to self-direct energy [8]. However, others have questioned energy justice's assumption of abundant energy "as a 'right' in relation to a transition to a fully renewable energy system" [5, p. 13] to illustrate the limits of energy justice. Clearly, justice in communal energy transitions is no simple matter, perhaps limiting our ability to achieve sustainable energy systems.

To move from assumptions of justice in these energy community technologies, we must investigate how we embed notions of justice into digital technologies. Speculative design is particularly useful to pose questions related to the values and assumptions we design with and for [10]. Raptis et al. [15] prompted user reflections on energy practices with a provocative artifact inspired by industrial aesthetics that prevented the consumption of non-renewable energy. Further, HCI research has materialized concerns of energy trading using personal hygiene technologies [14], as well as high-resolution energy data using application prototypes [16]. Thus, speculative design is a fruitful method for raising questions about modern energy systems, specifically notions of justice in P2P energy-sharing systems.

In this Work-in-Progress, we present Just Share It!, a speculative P2P energy-sharing system. Just Share It! is a prototype of a tablet application which uses energy consumption forecasts based on machine learning (ML) to predict future household energy consumption in a fictional energy community. By juxtaposing forecasted energy consumption with future solar energy production, users of Just Share It! are prompted to consider how they will engage in P2P energy-sharing. Specifically, users must choose how to engage in P2P energy-sharing based on a variety of energy justice values that materialize considerations for how Human-Computer Interaction (HCI) may design for justice in these systems. By embedding energy justice directly as a user choice in P2P energy-sharing, we are able to discuss new design considerations for energy community systems.

2 JUST SHARE IT!

To design Just Share It!, we draw on a previous qualitative study (semi-structured interviews and field visits), that we conducted in a European energy community. Here, we used Value-Sensitive Design to investigate energy justice in energy communities. Our objective was to gain insights into how HCI can design for energy justice in energy communities, as well as possible tensions herein. Results from this study solidified the relevance of energy justice for HCI and laid the foundation for our understanding of communal energy justice.

2.1 Prototype Description

To contextualize the design of Just Share It!, we wrote a short design fiction [10] concerning a fictional energy community engaging in P2P energy-sharing. This fiction serves to set up a world-making for Just Share It! to exist *within*:

> We are excited to welcome you back to Genera! Genera has been transformed into what might best be called an "energy community". Genera is our first step towards a local transition towards sustainability, where everyone can both contribute to and benefit from the transition to renewable energy production and consumption. Our houses are equipped with sensors that monitor energy consumption, as well as solar cells that produce renewable solar energy.
> You've already met your neighbors when you last lived in Genera. They are single mother of two, Sarah M., and couple, Mark and Julian. Sarah M. is infatuated with the sustainability, but has little time to truly take part in this, as she has focused on raising her two kids alone. Mark and Julian have long focused on growing their own crops and building furniture, seeing Genera as an opportunity to share their abilities.
> In the Just Share It! app, you can always view tomorrow's expected energy consumption and production, and collaborate on energy excesses and deficits. We hope you will aid Genera in becoming a united, self-sufficient front against the energy problems plaguing society.

In Genera, Just Share It! is a tablet-based application acting as the front-end of a P2P energy-sharing system. This system is imagined to use aspects of ubiquitous computing in the form of sensor networks deployed in user households to collect energy consumption data. These data are inputted to an advanced artificial intelligence (AI) system that produces household energy consumption forecasts and contrasts these with solar energy production forecasts. Community members are presented with the forecasts and must choose how they will deal with eventual discrepancies between forecasted energy production and consumption. Thus, Just Share It! functions as a diegetic prototype, as this system exists in "the world of the story" [10, p. 242], where members of Genera use the application for P2P energy-sharing.

As a speculative artifact, Just Share It! is currently a Figma prototype (figure 1). Energy consumption forecasts have been computed by training an eXtreme Gradient Boosting regression model on one Massachusetts household's data found in the Smart* 2017 energy consumption dataset [18], while the forecasted weather relates to the weather data from the same dataset. Solar energy production data is found in the SunDance dataset [18]. Participants can view forecasts of 'tomorrow's' energy excess or deficit (as predicted by our ML model) in the Figma prototype and interact with them to view prompts for managing P2P energy-sharing. While the prototype resembles traditional eco-feedback, it departs from previous approaches to P2P energy-sharing that focus on algorithmic energy-sharing [3] and minimizing user effort [11]. Instead, Just Share It! materializes "the idea, the plurality of the idea, and the associated connotations" [10, p. 241] of energy justice by literally asking participants to make choices that reflect notions of communal energy justice. This is enhanced by the prototype's name, which references the popular Nike slogan "Just Do It," hinting at P2P energy-sharing

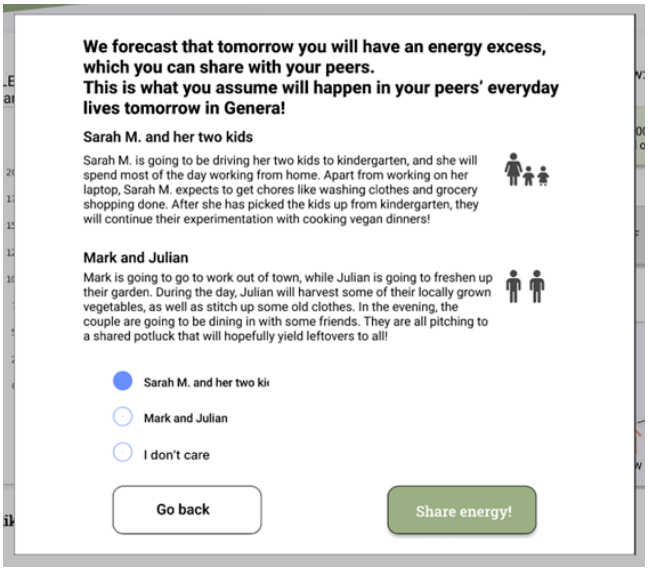

Figure 2: Recognition justice implemented in Just Share It!.

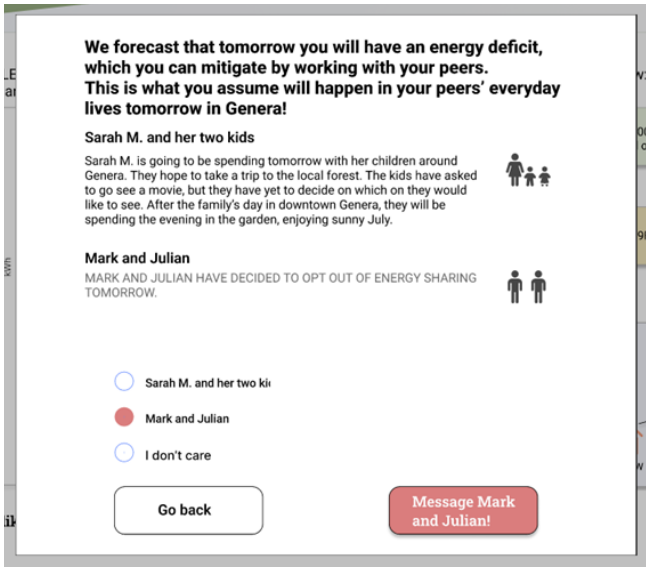

Figure 3: Procedural justice implemented in Just Share It!.

being an essential part of life that people just *do*. Through the speculative artifact, we want to stimulate imaginations of how we might design for energy justice in P2P energy-sharing.

2.2 Embedding Energy Justice

Central to Just Share It! as a speculative artifact is its materialization of energy justice, which we have materialized as a series of user interactive prompts. This can make often hidden aspects of algorithmic P2P energy-sharing systems tangible for participants, encouraging reflection on both implicit and explicit values relevant for designing such systems [8, 19].

Recognition justice concerns how energy communities recognize the rights, vulnerabilities, and histories of energy community members [1]. Our study highlighted that energy communities are expected to respect and engage with the unique circumstances of community members, and to treat and represent them respectfully. Just Share It! implements recognition justice through a simple text-based interface, shown in figure 2. Here, participants can share their forecasted excess of tomorrow's energy with two other community members. These community members, however, have vastly different circumstances. Specifically, Sarah M. is represented as simply having fewer opportunities to engage in limiting her energy consumption due to her status as a single mother of two. Mark and Julian, on the other hand, seemingly already engage in many sustainable practices while still having time and resources to spare. Participants must then consider how they consider community members' circumstances as defining how to share energy.

Procedural justice concerns the ability of energy community members to actively engage in the energy community [1]. We found that community members must understand energy community happenings, and use this to learn and collaborate at their own pace. Just Share It! engages with procedural justice through the interface shown in figure 3. Here, participants are forecasted to be in an energy deficit and must request energy from their peers. Using a similar text to recognition justice (figure 2), this prompt shows how community members Mark and Julian have opted not to engage in energy-sharing for the following day. If participants choose the option for Mark and Julian, they are prompted to message the couple and discuss possible energy-sharing. Hence, the interface surfaces considerations of how P2P energy-sharing must acknowledge that decision-making in energy communities should be continually contested.

Finally, *distributional justice* relates to the equal distribution of risks and benefits of energy communities [1]. Our study contextualized this as meaning that energy community benefits must be provided to energy community members, and that abilities to participate are equally distributed between all. Just Share It! implements distributional justice, shown in figure 4. Participants are prompted to decide how energy will be shared between other community members. This also surfaces the notion of preserving the excesses of the energy community inside the community to benefit others. Participants can use a slider to distribute their excess energy between two households in the energy community. The slider further tilts to the side of the peers being shared most energy with. Thus, participants are forced to concretize how they want to distribute their excesses in the energy community, and thereby the balance of distributional justice engendered by their choices.

3 DISCUSSION

Recently, P2P energy-sharing systems have become of interest in HCI as relevant trajectories of communal energy transitions toward sustainability [8, 14, 19]. However, critical voices have also highlighted that justice in such systems is not a given [1]. Just Share It! serves as an initial step for designers to critically engage with justice in P2P energy-sharing systems, and to reflect upon choices made during the design of such systems.

On the one hand, Just Share It! probes *how* notions of energy justice can be materialized in P2P energy-sharing systems. Researchers

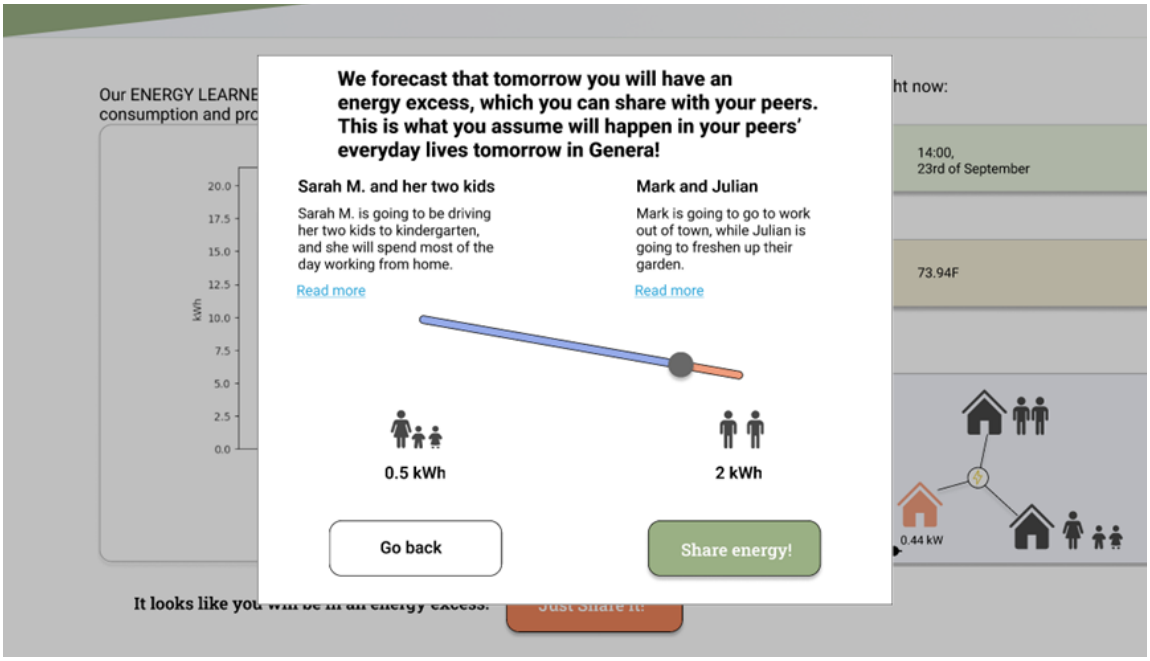

Figure 4: Distributional justice materialized in Just Share It!.

have highlighted the relevance of supporting decision-making [19], varied trading models [14], and technological diversity [8] in P2P energy-sharing and related systems. Just Share It! extends this work by materializing such decision-making and speculating on notions of energy justice. Hence, the speculative artifact serves to engage participants in considering how values and assumptions for energy justice should be implemented in P2P energy-sharing systems. For example, Just Share It! enables participants to read about the histories and vulnerabilities of energy community members as part of recognition justice. However, this begs the question – should individuals be prompted to recognize and act on such vulnerabilities themselves? This justice might also be implemented as an algorithmic recommender system to reduce the risk that vulnerable community members are further isolated. Just Share It! also provides participants with a large degree of personal information about community members. Milchram et al. [12] highlighted privacy and governance of data as an aspect of fair distribution of smart grid benefits. While we have not designed for the value of privacy in P2P energy-sharing, it is relevant to explore the conditions under which participants would be willing to share personal information, and how such sharing can be more actively integrated into Just Share It!. In future works, we plan to refine the design of Just Share It!, and use the prototype in field studies to understand how energy justice tenets are experienced and might be implemented in ubiquitous, ML-based P2P energy-sharing systems.

On the other hand, Just Share It! also highlights the limitations of energy justice for P2P energy-sharing systems. Algorithmic P2P energy-sharing may limit "widespread and deeper engagement with energy" [19, p. 10] by preserving energy as an ever-accessible resource for all. Just Share It! prompts participants to actively request energy in cases of forecasted energy deficits, instead of prompting them to actively consider limiting energy consumption. Questioning such notions is critical to ensure that communal energy transitions like P2P energy-sharing can transform our energy systems without relying solely on optimistic visions of technology [9] for reducing energy demand [4]. In this way, we also foresee that Just Share It! be used in reflecting upon the role of design for sustainable energy transitions, that can balance the rights of community members while also engaging with alternative energy consumption.

4 CONCLUSION

In this paper, we presented Just Share It!, a speculative P2P energy-sharing system that explicitly implements energy justice. Just Share It! functions as both a diegetic tablet-based application for P2P energy-sharing in a fictional energy community, as well as a speculative artifact that prompts reflection on just P2P energy-sharing. Building on our initial Value-Sensitive Design work for energy communities, we have presented empirically grounded speculations on what energy justice might look like in P2P energy-sharing systems. With this prototype, we have discussed how justice is a central concern for designers, both as design element, and as a consideration among many for designers of sustainable energy transitions.

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