Environmental Innovation and Societal Transitions 38 (2021) 98–109

Contents lists available at ScienceDirect

Environmental Innovation and Societal Transitions

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

Justice aspects of flexible household electricity consumption in future smart energy systems

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ARTICLE INFO

Keywords:
Flexibility
Framing
Science and technology studies
Electricity infrastructure
Users
System developers
Norway

ABSTRACT

As energy transitions advance through the introduction of renewable energy production and new types of energy demands, expectations for more flexible electricity consumption has risen on agendas among system designers and scholars. Social scientists have followed this development through studies of technological visions and users of new flexibility techniques (e.g. demand-side management, pricing, storage). Based on interviews with electricity systems developers and householders in Norway this article complements this body of scholarship and relates it to emerging themes in sustainability transitions research. We focus on end-user flexibility and operationalize the new concept of flexibility capital, developed within energy justice literature, to examine different framings of flexibility. The research examines how some householders have more capability of being flexible than others. Furthermore, we show how consumer understandings of flexibility are embedded in everyday life, and differs from systems developers, who primarily understands flexibility as acting economically rational and making cost-conscious decisions.

1. Introduction

Electricity infrastructures are deeply anchored in everyday life. The use of electricity is structured by institutional and social rhythms and carried out as part of multiple everyday habits. Currently, there is an increasing interest in making electricity use more ‘flexible’. This is thought to support the electrification of heating and transportation and the transition to an electricity infrastructure that integrates an increasing amount of variable power. Energy providers, policy makers, and energy researchers often focus on the technical and economic aspects of flexibility. In their conceptualizations, flexibility designates a characteristic of the whole energy system such as electricity distribution, a commodity that can be traded, or specialized flexibility techniques such as demand-side management, energy storage, and time-dependent electricity pricing (Blue et al., 2020).

Over the past years, many social science studies have critiqued these practices for their poor fit with everyday living conditions (e.g. Torriti, 2012; Schick and Gad, 2015; Skjølsvold et al., 2017; Silvast et al., 2018; Christensen et al., 2020). Scholarship has called for reconceptualizing flexibility to mean “an emergent outcome of the historical development of constellations of practices that make up social life” (Blue et al., 2020: 12). This focus on demand-side practices is joined by the new concept of *flexibility capital,* which means the capacity of energy users to shift their energy-using practices in time or space to make the whole system more flexible (Powells and Fell, 2019).

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https://doi.org/10.1016/j.eist.2020.11.002
Received 8 May 2020; Received in revised form 5 November 2020; Accepted 16 November 2020
Available online 9 December 2020

In this article, we combine these social science insights and use them to contribute to research on *end-user flexibility*. This key concept rests on several related premises: it points to (i) the capacities of users of energy to produce flexibility in their everyday lives; (ii) their potentials for interacting with the energy system; as well as (iii) how those interactions are envisaged among energy systems developers. By focusing on end-user flexibility, we contend that the impacts and benefits of such flexibility techniques are not necessarily distributed evenly across society, which means that such techniques should be evaluated not only in their ability to make consumption flexible, but also in terms of how fair their distribution of burden might be.

Analytically, we integrate concepts from energy justice and fair energy transitions literatures (Jenkins et al., 2016; Powells and Fell, 2019; Ingeborgrud et al., 2020) and the wider aspirations to make current energy systems 'smart' by integrating them with digital technologies (Skjølsvold et al., 2015; Schick and Gad, 2015; Throndsen and Ryghaug, 2015; Throndsen, 2017; Silvast et al., 2018). Our research question is: *How does the transition toward increasing flexibility in electricity distribution affect electricity users in terms of energy justice and fairness? How do technology developers and users frame flexibility? What implications do the difference between their framings have for sustainable energy transitions?*

The research presented in this article contributes to energy social science research by developing four arguments that respond to four research 'gaps' identified in the updated Sustainability Transitions Research Network (STRN) agenda (Köhler et al., 2019). First, we argue and demonstrate how flexibility techniques have bearings on people's everyday experiences of energy transitions. Second, the article provides a bridge between how future flexibility is envisioned by systems developers and how such futures are interpreted by prospective end-user providers of more flexibility, namely ordinary householders. We do this by examining both how developers and users frame end-user flexibility and highlight emerging tensions between these frames. Third, inspired by an interest in the energy justice aspects of energy transitions (Jenkins et al., 2016), we operationalize the recently emerged concept of flexibility capital (Powells and Fell, 2019) to explore the capacities of householders to become more flexible and how these capacities are framed both by electricity systems developers and users. Fourth and finally, we discuss the implications of the discovered mismatch between developer and user understandings of flexibility capacities for sustainable energy provision.

The article is structured as follows. We first review existing literature on flexibilities of energy demand and 'smart' energy systems and highlight our contribution to energy transitions research. We then explain our methods and empirical material ranging from systems developers to ordinary end-users. This part also explains how we draw from the concepts 'frame' and 'framing' developed primarily in Science and Technology Studies (STS) and the social sciences. After the analysis, we discuss and conclude by examining issues of energy justice and fairness and discuss implications for improving the understanding of promoting flexibility and energy transitions.

2. Theory: flexible designs and users in sustainability transitions

In energy social science and transitions research, the themes of flexibility and everyday energy consumption are connected to the growing interest in 'smart' energy systems. This term refers to making current electricity grids 'smarter' by means of digital infrastructures (see summaries in Skjølsvold et al., 2015; Sumpf et al., 2017; Silvast et al., 2018; Skjølsvold et al. 2020). For us, two key strands of this literature are particularly relevant. The first focuses on 'smart' as a professional project. Smart projects and challenges involve specific activities by incumbent energy companies (Heiskanen et al., 2018), conceptions of innovation and its governance (Hiteva and Watson, 2019), and research and development efforts (Skjølsvold and Ryghaug, 2015). This literature is joined by a common interest in how smart energy systems represent desirable technological, economic, and societal futures (Ballo, 2015)—futures in which imagined end-users are typically expected to become energy consumers that are more rational, cost-conscious, and information-sensitive than they currently are (Silvast et al., 2018).

The second line of literature probes 'real' or 'actual' people and has focused on innovative lead-users (Heiskanen and Matschoss, 2016) and households with their social interactions (Winther and Bell, 2018; Skjølsvold et al., 2017). Building on decades of social scientific insight (Aune, 2007; Lutzenhiser, 1992; Wilk and Wilhite, 1985), this research critiques economic rationality in smart development projects. It argues that energy usage is deeply embedded in everyday habits and shaped by wider energy cultures. Therefore, people only infrequently act as economic agents in the idealized manner expected of them by smart technology projects (Strengers, 2014; Throndsen and Ryghaug, 2015). Lately, more attention has been paid to the dynamic relations between technologies and practices, typically through seeing flexibility as a phenomenon anchored in collective, rather than individual, practices (Christensen et al., 2017; Shove and Cass, 2018; Torriti, 2019).

We want to reiterate the summary of these social science findings on smart grids projects, since these have been handled extensively in the literature (for reviews, see Silvast et al., 2018; Winther and Bell, 2018; Christensen et al., 2020; Skjølsvold et al., 2017). The foundational vision of smart grids was reducing investments in physical infrastructure by integrating energy infrastructures with digital infrastructures, including envisioned advanced computer controls (Slayton, 2013). Ever since the first smart grids pilots, the consumers have been expected to become more 'active' within these smart grids. However, providing more detailed and real-time information to these consumers does not often lead to long-standing changes in their behaviour (Hargreaves et al., 2013) While developers of smart grids assume that consumers are rational, essentially economic profit-maximizing agents, the developers also know that people only sometimes behave in this expected manner. Therefore, some developers find considerable appeal in technologies that bypass these issues and rely on automation – for example, customers purchasing software that manages the switching of electricity suppliers automatically or remote control of household appliances – that offers a more plausible way to intervene in consumers' energy demand.

We do not seek to reproduce this familiar narrative. Instead, our analysis takes the existing literature on smart energy in social sciences and transition to important new directions, in four complementary ways. Köhler et al. (2019) have provided useful guidance for developing these tasks in their new agenda for sustainability transitions research, where they outline a future research area on transitions in practice and everyday life. Firstly, social science perspectives on flexibility and smart systems supplements this research directly—especially because "the STRN [Sustainability Transitions Research Network] community have tended to isolate everyday practices from the wider socio-technical systems that service them" (Köhler et al., 2019, p. 13). This article also generates insights on the everyday practices of householders and links them to the wider discussion on the flexibility of socio-technical power grids.

Secondly, Köhler et al. (2019, p. 14) specifically note that "there is a need for broader frameworks that bridge production and consumption at system, technology and product levels." Providing such an overarching framework is not simple and opens a long-standing and complex theoretical debate on designer-user relationships in STS (Silvast et al., 2018) and energy social research (Stephenson et al., 2010, 2015) more broadly. However, we see this as an opportunity to further develop frameworks for examining how developer and user framings are co-constituted between different sites of power infrastructures (e.g. Silvast and Virtanen, 2019).

Thirdly, transitions research has started to expand its focus on users to also encompass social inclusion, ethics, and social differences in sustainability transitions (Jenkins et al., 2016; Köhler et al., 2019, p. 13; Ingeborgrud et al., 2020). This interest informs the key contribution of this article: We are especially interested in addressing the ethical consequences and energy justice issues that accompany imperatives of increased flexibility. The requirements for flexible end-users to meet energy transitions imply that households have specific resources and capabilities to provide this; they must have *flexibility capital* (see Fig. 1): "the capacity to responsively change patterns of interaction with a system to support the operation of that system" (Powells and Fell, 2019, p. 57). Having flexibility capital entails both owning technologies and using electrical loads that can be flexibly managed. Affluent energy users are more likely to own energy technologies that afford flexibility (such as batteries and smart appliances) and consequently have significant loads that are possible to manage. Less affluent energy users are less likely to own such technologies that can act as buffers between their daily practices and the flexibility adjustments. Consequently, their flexibility capital is mostly derived from changes to daily activities and routines. However, the link between flexibility capital and financial resources is not always linear as Fig. 1 suggests; they are partially independent dimensions of everyday life. For example, retired people or people working from home may have more possibilities to switch their energy use at home simply because they might spend more time there.

So far, the concepts of flexibility capital and flexibility justice have remained mainly conceptual perspectives and need empirical advancement. In this article, we aim to contribute to this by using the concepts to unpack our material and discover hitherto unrealized implications for justice in 'end-user flexibility' projects and energy transition more generally. This constitutes our fourth aim. As we show below, Norway—an affluent and energy-intensive economy—offers a unique site in which to develop these interests further, both conceptually and in the applied sense.

3. Material and methods

This article collected its materials from two primary sources: first, accounts from systems developers that were aligned with a Norwegian national research center focused on realizing a 'flexible' and 'robust' electricity grid grounded in a systems perspective and

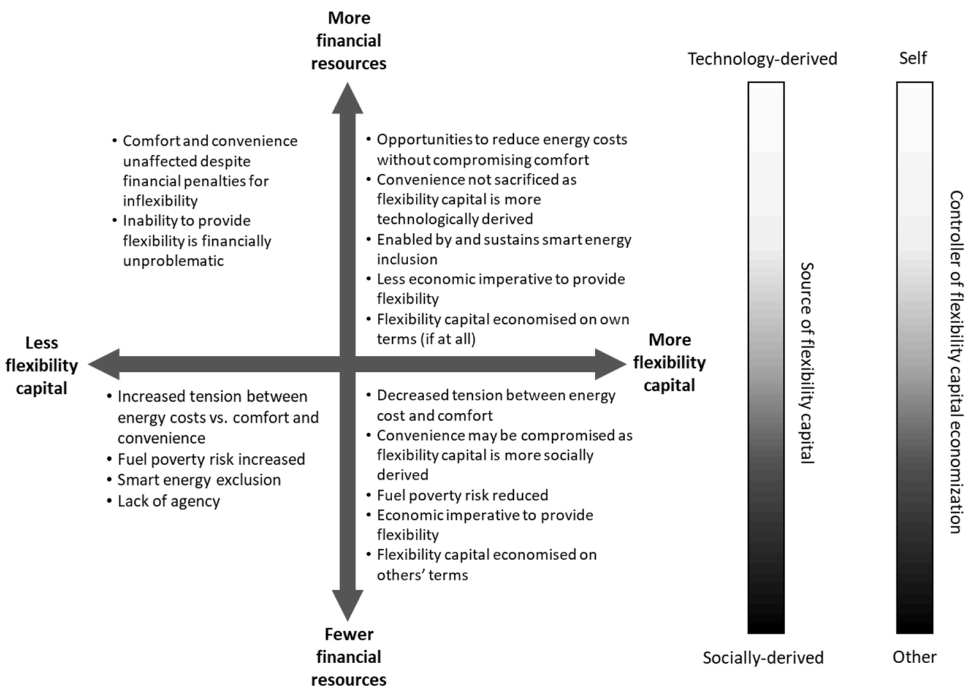

Fig. 1. The interactions between flexibility capital and financial resources. *Source*: Powells and Fell, 2019.

including a strong research interest in 'consumers'; and, second, accounts from different kinds of ordinary Norwegian households that are currently envisioned as part of the flexible power system. Our analysis is based on the idea of these being two relevant 'sites' of the infrastructure. By combining detailed inquiries of concerns on these sites with examining how these sites relate to one another, we aim to pursue further understanding of flexibility across sites of infrastructures.

To carry out these tasks, the analysis draws from the concepts of 'frame' and 'framing' as developed in infrastructure studies and STS by Silvast and Virtanen (2019). These concepts have two relevant roots: a sociological root where frames and framings point to definitions of problems at hand and are means for people to refine and characterize these problems with meaning and interpretation (Jerneck and Olsson, 2011); and an economic sociology and STS root where frames and framings point to technical simplification, typically by economic models such as introduction of market mechanisms (Callon, 1998; Silvast, 2017). Combining these two meanings of frames allows us to examine different aspects of meaning-making among systems developers and householders, including mundane frames and technical simplifications, such as models of economically rational behavior. This comparison furthermore highlights the diversity of frames and unpacks the potential power relations behind them—themes also highlighted by flexibility capital research (Powells and Fell, 2019). Typically, systems developers frame consumers as rational and cost-efficient, but we want to highlight how the users' framings show more divergent capabilities to be these rational consumers (Silvast and Virtanen, 2019, 465–466).

To capture these different aspects of frames and framings, qualitatively rich materials are needed for analysis. The empirical material comes from audio recorded, transcribed and coded qualitative semi-structured interviews (Kvale, 1996) with 26 householders and 11 actors in industry and research. All interviews were conducted in 2017 and 2018. The material was analyzed using a stepwise-deductive inductive (SDI) method (Tjora, 2017), where the analysis moves between empirical material and concepts, linking these continuously as the research progresses.

For the householders, we aimed at including adult users of electricity. A deliberate attempt was made to increase the diversity of interviewees in terms of socio-economic parameters, such as type of house and household, gender and age. Personal networks were used to invite householders to participate in interviews. To make sure that the interviewees did not feel pressured to participate, they were asked by a third party (friend or college of the researchers) to contact the researchers themselves. The wide selection of interviewees resulted in recruitment of householders varying in: educational-, work- and family backgrounds, life situations, income, age (from young adults to seniors), geographical locations (mid, east and western parts of Norway), type of households (old/new apartments, townhouses, detached houses), and located in rural areas (living separately in the country site), in suburban areas (spacious residential areas a good distance from city centers), and in urban areas (in or close to the city center). See overview in Table 1. The main themes in the interview guide were everyday life, flexibility, consumption and household. Householders were asked to share experiences, reflections and expectations about their own current and future energy consumption, focusing on possibilities for flexibility in the household. All householders were interviewed in their homes, which allowed for gathering accounts of electricity flexibility in a familiar environment where electric technologies are being used. The data consists of 17 households and 26 subjects.

In section 5, where we analyze the material from the householders, we use the term "flexibility work" as a way to describe the practical side of shifting or cutting electricity use. This is to underpin that this task is actual work, similarly to other unpaid work that needs to be done in a household. Some households have the capital to outsource domestic chores, other do not have this available surplus. However, we interpret these tasks as work.

The 11 actors in research and industry (Table 2) worked within smart energy development and were chosen to add knowledge and perspectives to the research based on their competence, experiences, and relevant roles (Tjora, 2012, p. 145). The questions were open-ended, probing future challenges in the electricity system, expectations toward end-users, and possible flexibility techniques. Most of the developers had educational backgrounds in electrical power engineering and worked with digitalization of the electricity grid through research, in grid companies, expert groups, or in relevant centers.

Table 1
Interviewees, householders.

Gender	Age	Household	Occupation	Building	Area	Location	Climate
Female and male	Sixties	Couple	Radiograph, engineer	Detached house	Suburban	South	Oceanic
Female and male	Sixties	Couple	Nurse, engineer	Detached house	Suburban	South	Oceanic
Female and male	Sixties/ seventies	Couple	Lawyer, educator	Apartment	Urban	South	Oceanic
Female	Sixties	Solo	Social worker	Rowhouse	Suburban	South	Oceanic
Female and male	Sixties	Couple	Engineer, educator	Detached house	Suburban	Mid	Humid continental
Female and male	Sixties/ seventies	Couple	Geologist, consultant	Apartment	Suburban	Mid	Humid continental
Female and male	Twenties/ thirties	Family	Writer, consultant	Duplex	Suburban	Mid	Humid continental
Female and male	Thirties	Couple	Consultant, IT	Rowhouse	Suburban	Mid	Humid continental
Female	Thirties	Solo	Psychiatrist	Apartment	Urban	Mid	Humid continental
Male	Thirties	Solo	IT	Apartment	Urban	Mid	Humid continental
Male	Fifties	Couple	Doctor, engineer	Detached house	Urban	Mid	Humid continental
Female and male	Twenties/ thirties	Family	Social worker, accountant	Duplex	Suburban	Mid	Humid continental
Male	Sixties	Family	Salesperson	Smallholding	Rural	East	Continental
Male	Thirties	Couple	Construction worker	Detached house	Rural	East	Continental
Female and male	Thirties/ forties	Family	IT, IT	Detached house	Rural	East	Continental
Male	Sixties	Family	Unemployed on benefits	Smallholding	Rural	East	Continental
Female	Forties	Couple	Nurse	Smallholding	Rural	East	Continental

Table 2
Interviewees, systems developers.

Field	Position	Gender	Background
Research	Research scientist	Female	Electric Power Engineering
Research	Professor	Male	Electric Power Engineering
Research	Senior researcher	Female	Science and technology
Research	Senior researcher	Male	Electric Power Engineering
Research	Professor	Female	Electric Power Engineering
Industry	Senior engineer	Male	Energy and Environmental Engineering
Industry	Senior advisor	Male	Civil engineer
Industry	Research and development	Male	Industrial economics and technology management
Industry	Grid development	Male	Civil engineer
Industry	Senior engineer	Male	Electric Power Engineering
Industry	Grid developer	Male	Systems and Control engineering

The empirical material in this study is collected in Norway. Issues with high power output and thus flexible electricity use have not been pressing in the hydropower nation of Norway. Therefore, these issues have not been on the agenda for the average householders and electricity user that have often associated a high level of energy consumption with comfortable life (Winther and Bell, 2018; Aune, 2007). However, due to increased pressure on the electricity grid, particularly due to electrification of the transport sector, there is growing interest among industry and policymakers to incentivize private householders to contribute with flexibility (e.g NVE, 2018; Norwegian Environment Agency, 2020; Christensen et al., 2020; Skjølsvold et al., 2018). Even though smart electricity meters were installed with all Norwegian households in 2019, the incentives enabled by this technology are still hypothetical as they have not yet been put into action. To contrast Norway with other European countries, by 2014, there were nearly 45 million electricity smart meters already installed in Sweden, Finland, and Italy, and 16 EU Member States had promised to complete the roll out of this smart metering by 2020 (European Commission, 2014). These early installations demonstrated multiple kinds of benefits including “the electricity efficiency and shifting benefits (electricity cost savings) available to customers, with important benefits also obtained by the DSO [Distribution System Operator] from savings in meter reading and operations costs and reduction in commercial losses” (ICCS-NTUA and AF Mercados EM, 2015: 6). We do not argue that the Norwegian context is at a very early stage of technological development, but rather that the issue of increased consumer flexibility is rather hypothetical and projected toward future rather than already experienced flexibility. That context clearly shapes the way in which developers and users respond to issues of flexibility and flexibility justice in what follows.

Our interview study is shaped by the possibilities and limitations of all qualitative studies, which are by now well-known among social scientists. A brief summary is that most of our informants are from one project or relatively small set of households in one country. This research design uses “theoretical sampling” rather than “probabilistic sampling” (for further details of sampling techniques and research design in qualitative research, see e.g. Alasuutari, 1995; Gobo, 2008). Therefore, we cannot generalize about what happens in all households or all technology projects everywhere in terms of flexibility capital. What we do offer are qualitative vignettes into the real live experiences and thinking among technology project experts. This addresses our research questions and contains an important contribution to the literature.

4. Developer framings of flexibility providers

The systems developers interviewed in this study worked on techniques to tackle challenges in the grid, which included making better use of what they saw as the ‘flexibility potential’ of private households. In the following part of the article, we investigate systems developers’ framings of peak load problems in the electricity grid and how they framed end-users’ consumption to be problematic, with a focus on energy justice and fairness. We explore in what way the developing experts believed end-users could actively or passively be involved in flexibility work and how incentives of information, price signals, and automation were needed to realize the unexploited flexibility potential in end-user households and thereby better synchronize the consumption and the capacity in the grid.

4.1. The peak problem

The systems developers expressed that peak loads are problematic for the current grid infrastructure. An electrical power engineer drew on similarities between the grid and a highway, explaining that if something could be done with the very limited, but problematic peak hours, it would not always be beneficial to expand the physical grid:

> Perhaps something can instead be done about the top load we only have for a few hours each year (…). Otherwise, there will be a “traffic jam” on the highway one hour per year, which leaves us with the need to invest in a four-lane highway based on that one hour.

Limiting the physical infrastructure was viewed as preferable, as an overblown infrastructure was considered a waste of resources. Therefore, within the frame of limiting the physical grid, there were expectations of available flexibility resources ‘elsewhere’ to assist in tackling the few, but critical peak load hours. In the developers’ framing the flexibility potential resided in end-users in households who could, in their view, help cut or smooth out the highest peaks of consumption. This argument is of course not new but repeats the promise of smart grids since their initial days in the early 2000s (Slayton, 2013). Even then, the assumption was that an electrical grid with advanced computer controls would increase efficiency and security by reducing the physical infrastructure that would otherwise have to sit idle outside of the peak hours. That this promise is repeated by systems developers in Norway shows that these visions have not stopped circulating among technological project experts.

4.2. End-users flexibility potential

Many of the system developers echoed a similar framing: end-users should be more involved in flexibility work, because they were perceived to holding unused flexibility resources which could be tapped into through a number of methods. In other words, from a systems development perspective, flexibility capital is abundant amongst end users. One method involved making agreements with third parties that would allow them to override consumption in critical hours (e.g. remotely lowering temperature in e.g. hot water tank or bathroom tiles). Another would be to install automatic solutions (e.g. timers). Another option entailed manually shifting consumption away from peak hours (avoid the use of e.g. washer, dryer, induction hub, and EV-charger, at the same time). Information or economic incentives (punish or reward) were discussed as means to promote this flexibility. These are, once again, not new promises or problems. However, in Norway, these are still mainly future issues, given the very recent smart meter rollout. Our interviews illustrate this: what was at stake was not an experienced empirical flexibility, but one located in an uncertain future. These findings are stressed here because they suggest what the developers thought would constitute 'proper' and 'fair' use of future everyday electricity.

As one interviewee from a grid company expressed, hypothetical future flexibility can be unreliable. As a contrast, he highlighted the company's need for what he termed 'predictable flexibility'. He noted: "*It [flexibility] needs to be available Christmas Eve and on a cold day in February.*" This illustrates that from a grid company's perspective, flexibility primarily caters to the needs of the electricity grid, not the needs dictated by everyday use and practices – even on Christmas eve. It also illustrates that systems developers are sensitive to the fact that end user flexibility capital is not static, but that the possibilities of providing flexibility changes with circumstance.

Despite uncertainty, the idea that flexibility would be important in the future energy system was widely shared. The transformation of end-users into 'active consumers' was part of this. However, the developers differed in their views on how willing, interested, or competent future households would be. Some of the techniques discussed called for rather intrusive changes in energy related activities, such as manually changing daily routines (e.g. cleaning at other times), while others were meant to be implemented and operate without any involvement from end-users (e.g. timed charging). Lack of interest and knowledge about problematic peak loads amongst the householders was seen as a great challenge, as the developers thought this could result in an unwillingness to contribute to flexibility.

Some system developers pointed towards a contradiction in what they saw as a gap in the population, where end-users would protest changes in the electricity supply system while simultaneously being unwilling to participate in the collective effort that they perceived flexibility to be. A system developer said:

> Not many [people] like that we are building [power] lines, windmills or anything. Therefore, if they do not want us to build a bunch of new lines and pay a lot for it, then we need to do something with the grid we have. Make the most of it.

The dual view on end-users as both profit-maximizing and uninformed has commonly been used as an argument in previous debates about energy market liberalization (e.g. Karlstrøm, 2012). Some system developers were explicit, stating that the core challenge was a lack of interest and willingness amongst most people. The framing of end-users as being mainly motivated by economics while also lacking interest and information that would allow them to become pure, idealized economic agents was translated by the developers into a set of techniques that would serve to activate and transform 'passive' end-users into active flexibility providers.

We identified three 'ideal typical techniques' dominant amongst the developers: *information,* which is intended to change knowledge and attitudes of end-users; *economic incentives*, which are meant to stimulate active choices; and *automation*, which would automate or outsource electricity management and energy choices. Since these techniques have been handled extensively in the literature (see reviews in Skjølsvold et al., 2018), we do not elaborate on these findings which focus on changing routines, incentives to do this, and promises of automation such as remote control of household technologies. In sum, we found that the system developers were generally positive to an energy future where everyday lives are widely preprogramed.

5. Flexible lives in the electricity grid

In this section, we move to householders and elaborate on how the realities of everyday lives among householders both mirror and differ from the developers' framings and how the developer-proposed flexibility techniques could create tensions and even conflicting framings of what flexibility entails on a practical level.

5.1. Flexibility, why and for whom?

End-users generally welcomed more information about changing their energy consumption to better fit the needs of the electricity grid. They especially expressed interest in the reasoning behind the need for their active participation. In fact, many mentioned that the interviews for this study was the first time they heard of potential peak hour challenges in the electricity grid. Some asked for sources of available information, and some questioned the fundamental need for using end-users as a source for flexibility as opposed to expanding the grid. A woman in a couple, living in a rural area on a smallholding said:

> First, one needs to have enough knowledge to understand that there is a point to this. That is the first premise; the knowledge that this is important. Because this will involve both individual consumers and a societal context, it creates a larger issue. And, then you have the question: is expanding the grid really a problem?

In addition to questioning the need for active participation of end-users, some of the householders expressed skepticism concerning whom will benefit from their flexibility. On the one hand, end-users did not like the idea of industry, whether grid companies or third parties, gaining economic profit from householders' flexibility efforts. On the other hand, reasons framed as acting in solidarity with the environment, the local community, or society in general were considered valid reasons to engage in flexibility work. Some householders stressed the importance of moral choices and efforts regarding collective good versus corporate profit, which is also supported by Throndsen and Ryghaug's findings (2015). A man, living in a couple in an apartment in an urban area, said: "*We are trying to separate between things we just do because it is OK to do it, and the things we do in solidarity.*"

5.2. Doing flexibility work

Every interview with householders featured discussion of how to practically smooth out electricity use in everyday life. The users themselves had ideas for how they could practically do flexibility work. Some proposed moving the consumption away from the household, such as showering more frequently at the gym or brewing coffee and charging devices at work. They were aware that this would not entail cutting their own energy consumption, only moving the time and location of consumption. They also recognized that this would be limited to mobile devices and certain activities.

In terms of doing flexibility work *within* the household, the householders expressed a range of ideas for shifting or cutting electricity consumption. These included: using electricity demanding household appliances and devices at off-peak hours; using timers or settings to delay start on appliances; remotely controlling appliances, e.g. by using apps; using alternative energy sources; and consuming less electricity in general. For some householders, this change would require rearranging everyday activities to avoid consumption at peak hours; investing in new, smart and energy efficient appliances; gaining knowledge in order to perform flexibility work; all in all it would require substantial resources to be capable to shift or avoid high use of electricity at peak hours in an efficient way. In other words, it would require increased *flexibility capital.* For others, optimizing flexibility performance of the household would involve outsourcing control or making small adjustments to their everyday life, such as setting timers, remotely controlling or delaying the start of 'smart' devices they already have installed. Therefore, the ability of householders to perform flexibility was closely linked to material goods and resources they possessed - how much flexibility capital they had. Fig. 2 summarizes and illustrates the four typical ways of doing flexibility work according to end-users.

5.3. Conflicting issues

The reflections around flexibility introduced safety concerns. Potential water or fire hazards were repeatedly included as an element of worry when discussing the practical consequences of flexible consumption, such as the use of household appliances during night-time or when absent from the household. One householder, a woman living in an apartment in an suburban area with her partner, stated that she believed she would make fewer safe choices if she was encouraged to avoid consumption at peak hours:

> I would turn the washing machine on. I think I would gamble on it. You are not supposed to put on the washer when you go to bed or leave the house, but I think I would do many more poor choices when it comes to safety, in order to use electricity at the "right time" when it is cheaper or when we should use it.

The quote demonstrates the different framings between systems developers—focusing on market mechanisms and incentives—to householders who framed flexibility by its consequences in everyday life and even included risky practices within this frame.

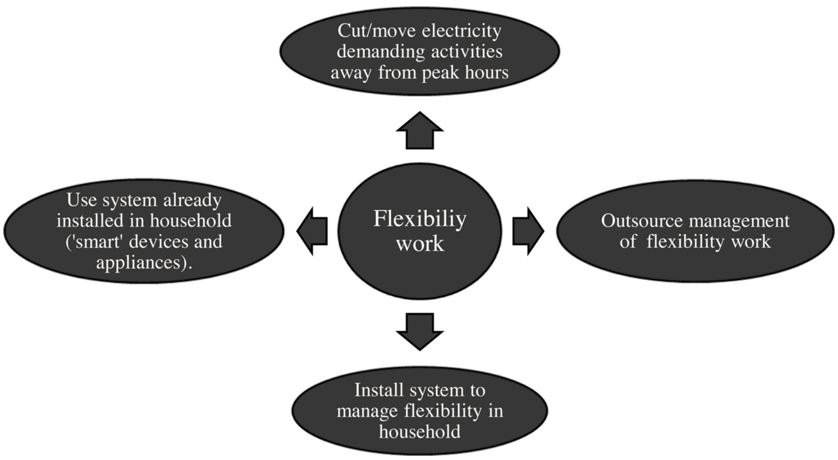

Fig. 2. Typical ways of doing flexibility work in household.

We also found that many of the householders described themselves as conscious and moderate users of electricity, even though some expressed that they could do more to shift or change their consumption away from peak hours. The householders did not frame themselves as disinterested or unwilling to change their consumption habits. Willingness and interest were linked to their values and resources, and the householders were open to provide flexibility if the reasons for that flexibility were benefitting the household, local community, society or the environment. We found the householders to be struggling with conflicting interests when they tried to imagine how they would practically incorporate a more flexible electricity consumption in their daily life without compromising (too much) with interests of safety, comfort, household economy, control, and everyday life.

These kinds of issues were not problematized by the system developers but point to an interesting contradiction also in the flexibility capital concept in households. It seems as if some interviewees could see fairness issues arising among other households or the local community, but not always among their own practices. In everyday life, the idea was difficult to understand and conceptualize appropriately, or at least, derive it from any singular interest such as economic profit. Flexibility capital is still implicit to these considerations but manifests as part of everyday life and its habits, including perceptions about comfort and control, and including perceptions about others and the community, which embeds it firmly in the everyday life practice but also makes it more opaque to the analysts and to people themselves.

5.4. *Price signals*

According to the householders, power demand tariffs and new price schemes would probably change some of their practices, but not to the extent that it would affect their everyday rhythm too much. A man, living in a couple in an apartment in a suburban area, stated that it needed to be "*bright and warm enough to sit still, even if the prices become higher.*" The impact of economics varied between end-users in terms of importance, as also found in previous social science studies; prices are but one aspect of demand response actions that are shaped by myriad household competences, kinds of engagement, and flexibility devices themselves (Christensen et al., 2020).

As demonstrated, we found that the householders problematized the system developers' framing of end-users' motivation and interests. From the system developers standpoint, the solutions seemed straight forward: automation (to relieve the need for active human involvement) and pricing signals (to [de]motivate [un]wanted behavior), preferably in a combination. However, the householders' everyday life experiences demonstrate a gap between user-experiences and developers.

5.5. *Loss of control*

The systems developers wished for flexibility technologies that need less human involvement. Techniques allowing for this were framed as more predictable for the grid and easy for the average end-user to implement or agree to, especially when they were combined with economic rewards from using them. Implementation of automation in the household were mainly referred to as the installation of smart devices or timers and the involvement of third parties (e.g. aggregators) who can override the consumption in critical hours.

Implementing automation and including third parties in the orchestration of the household's electricity supply were not viewed as appealing to all of the householders in the study. One claimed that he was not interested in smart solutions as they are not "idiot-proof," reasoning that it was just one more thing that could stop working. Having the control within the household was preferred, as the ability to overrule the system (if necessary), was possible. Using the water heater as an example, a family father, living in a duplex in a suburban area, said:

> I'd like to know that now we don't have warm water, and now we do have warm water. And, if we don't have it, it is because I've forgotten to set the timer or turn it back on. Then it is my fault. […] Then it is my incompetence that makes me suffer, but I still have my freedom and the ability to control it myself.

Some householders also found it problematic to potentially let a third party override some consumption decisions, even when it was framed as unnoticeable in addition to benefitting the grid. The main worry was the loss of control if something out of the ordinary were to happen in the family or household (e.g. illness). Therefore, they themselves would prefer to be the ones in charge and limit their consumption manually in critical hours in the grid. This goes for involvement of third parties and non-overridable automation techniques. The general issue with loss of control among users of flexibility mechanisms are widely discussed in energy literature (e.g. Fell et al., 2014; Paetz et al., 2012).

Other householders claimed that they would *not* mind a third-party controlling sources of energy demand, if the subjects could perform their everyday activities as planned. A male interviewee living in a couple in a rowhouse in a suburban area, said that given the choice between a third party having control or the householders being in control themselves, he would prefer the latter, but continued "*then again, in the bigger picture, when the third party perhaps has some statistics, some measures, has something, and a responsibility, then probably, why not?*". The householders were asked if they would place any restrictions on handing over control and if they would want something in return. When framing flexibility as something that could benefit the power grid itself – as a common benefit for all users of the grid-, some householders were very positive towards having a third party involved.

When asked if they wanted an economic compensation in return for their flexibility, a female householder, living in a duplex with her family in a suburban area, claimed that it would "feel weird" to be economically compensated if the whole point of being flexible was for it to be beneficial for all end-users. Another householder, a female living in a couple in a rowhouse in a suburban area, who did not mind outsourcing control and did not want anything in return, reasoned: "*I think it is about community. As long as you have the freedom to do normal things, (…) [not that] you must turn off the lights and can't make dinner.*"

A third householder, a man living with his family in a detached house in a rural area, even claimed that the involvement of third parties in the household and buying services, rather than owning appliances, was the next natural step of evolution; *"You don't buy a fridge in the future, you buy a service (...), which is cooling. It is a fridge, but you don't have any ownership to it."* In this framing, flexibility work for end-users is not necessary, as objects (e.g. the dishwasher) are replaced by services (e.g. the washing of dishes).

We found that when some of the householders discussed involving external actors in the home, they believed they would lose control. Having the control themselves was framed as an experience of autonomy and freedom. For others, the link between autonomy and involvement of external actors in the household's electricity orchestration was more loosely connected. Still others believed the outsourcing of control to be beneficial, given that they had the freedom to perform activities as they pleased in the household (see also Paetz et al., 2012; Darby and McKenna, 2012; Fell et al., 2014).

6. Discussion

This article studied framings of electricity end-user flexibility among systems developers and ordinary end-users of electricity. We found clear differences and tensions among these frames especially in how they expected householders to become more flexible. The systems developers described the ideal of an economically rational user in their framing. From this point of view, householders were not seen as flexible enough and lacked willingness, interest, abilities, and knowledge to become providers of flexibility to the electricity grid. These valuations linked to judgements on individual users, who should exercise rational behavior according to the developers. This framing clearly 'disembedded' users from their relationships to material, economic, and other constraints of everyday life. For instance, the developer frame did not focus on unevenly distributed capacities and flexibility capital. However, these capacities made some householders more capable of shifting their energy consumption than others as we showed and should hence be acknowledged.

The studied end-users valued flexibility also as a moral issue. Their valuations were primarily framed by the moral economy of the household and constraints of everyday practices. The end-users were concerned with how to practically incorporate flexibility into daily life and what kinds of impact the incentives, as envisioned by developers, would have on everyday living conditions. The end-users were not inflexible as a result of lacking 'rationality,' as assumed by the developers. On the contrary, most users showed visible interest, competences and assets—that can be recognized as high flexibility capital—for adapting to the external incentives and mechanisms meant to promote end-user flexibility.

Flexibility capital manifested on several social and material dimensions in our findings. The key dimensions were installed technological capacities (e.g. automated meter reading, smart household devices); the capacities to act and engage with flexibility (e.g. practical competence, perceptions about risk and risk taking); and economic constraints (e.g. financial assets, household purchases, investment decisions). Households with high flexibility capital possessed capabilities in several of these dimensions. Yet, our results also connect high flexibility capital with awareness and interest as capabilities: some users were more informed of the options that they have (such as using appliances at different time of the day) and were interested in learning about mechanisms and incentives promoting end-user flexibility.

In contrast, low flexibility capital was indicated by lacking capabilities on several related dimensions. Some householders found it very difficult to understand their own abilities for doing flexibility work, which was seen as a strain on their financial resources, available time, and interest to be involved. A low flexibility capital was also indicated by a lack of actual options to do different forms of flexibility work, as illustrated in Fig. 3.

Hence, in households with low flexibility capital, time and freedom in everyday life would be negatively affected if they are

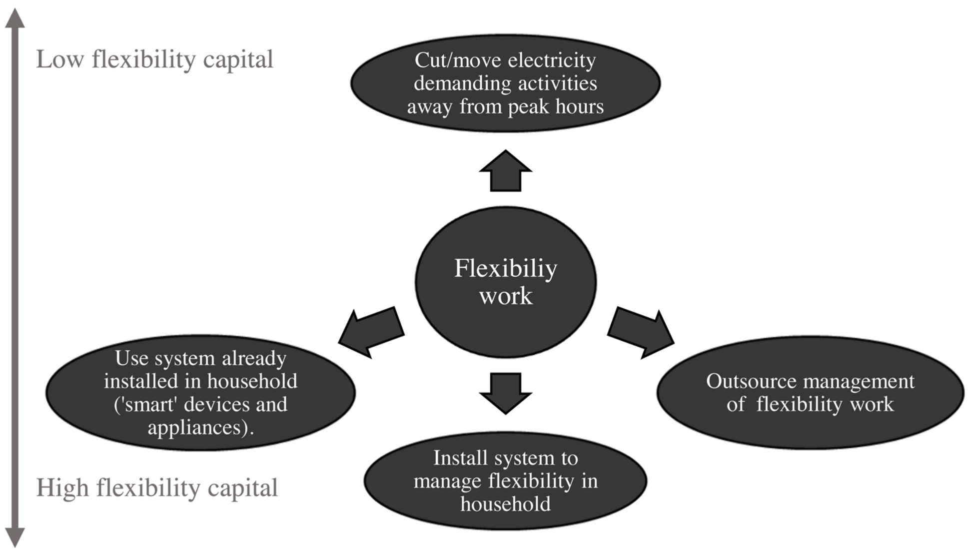

Fig. 3. Options for doing flexibility work in household, considering flexibility capital.

punished for their perceived ‘inflexible’ consumption. In these manners, flexibility has the potential to generate conflicts of interests and a tug of war for end-users and the contexts of everyday activities, scheduling, personal economy, fire safety, and comfort. These challenges may be reinforced by difficulties in balancing paid and unpaid work, family/home life and leisure, and other “time-squeezes” amongst the practical considerations in everyday life, which is often discussed in energy literature emphasizing gender and end-users (e.g. Strengers, 2014; Tjørring et al., 2018; Johnson, 2020). Our empirical material suggest that the female householders were more concerned than their male partners with flexibility work conflicting with daily chores and domestic work, as they used this as examples when discussing potential concerns for future end-user flexibility incentives and mechanisms in the household.

On that note, when looking into the division of work *inside* households, we see that worldwide, women tend to spend more time doing domestic work, compared to men (OECD, 2018). In addition, women are also often left with the extra mental and invisible workload of logistically organizing the daily activities and domestic work within households – often referred to as the third shift (Smeby and og Brandth, 2013). Norwegian couples disagree a lot about distribution of domestic work and economy (van der Lippe et al., 2014), and those households who have the capital to choose to outsource some of the domestic work may have a lower conflict level (Isaksen, 2001).

These gendered dynamics are suggested by a set of emerging studies on smart energy and a brief overview is useful at this point. Some studies have shown that in pilot projects, more typically the male was supervising the in-home display and telling his family when to use and when to not use electricity intensive appliances (Skjølsvold et al., 2017). The seemingly harmless and neutral in-home display became a source of conflict within the households (Winther and Bell, 2018).

Others also suggest that there is a gender dimension when it comes to performing what we describe as flexibility work. Turning Strengers’s (2014) critique of visions of “resource men” in technology projects upside down, Johnson (2020) suggests that women risk becoming a “Flexibility Woman” herself, organizing the households chores and electricity consumption with manually avoiding or shifting consumption away from peak hours, in order to access “the cheaper, greener electricity for the future”.

With these literature findings in view, the flexibility project studied in this paper contributes to an individualization of a structural flexibility-problem and may add to the burden of unpaid domestic work for households with less available flexibility capital. We also suggest that flexibility work may be too easily added to existing load of unevenly distributed unpaid work within traditional households – often disfavoring women.

As we have shown, the research on flexibility capital and the impact of social differences – notably gender – in energy demand relates to several earlier works on similar topics. In this sense, the concept of “flexibility capital” is not introducing an entirely novel research program for scholars, but more precisely complementing and advancing similar conceptual tools, such as energy justice research (Jenkins et al., 2016). Indeed, flexibility capital was built from the energy justice literature, but its core contribution is explicit expansion to energy flexibility and its justice implications (Powells and Fell, 2019). We can argue – and our findings have confirmed it – that flexibility in households and among technology developers has unique and original characteristics that need to be examined and these highlight new aspects of flexibility but also of energy justice in doing so.

As research into flexibility justice is still scare, we see empirical inquiries as a particularly promising route to further this research area. The analysis here justified the usefulness of the concept and unearthed several justice implications that we could not have discovered without operationalizing and applying the concept. In this sense, the research has contributed to better understanding of energy transitions and what the associated flexibility would mean in everyday life and among developers. But it is also important to stress two limitations of our conceptual and methodological tools. One is that the studied technological development experts were not using this kind of terminology of fairness, hence it is a reconstruction by the social scientist and follows the spirit of STS analyses, where values and tensions are discovered among technological tools that were configured differently originally. These established framings need to be dealt with explicitly, as we have done here.

Two, and related to the last point, it is important to notice that also in everyday life, justice and fairness implications are not always apparent, hence social scientists need to pay careful attention to peoples’ own conceptualizations about these issues. Solidarity with the environment, the local community, or society in general were considered as part of flexibility among households, which indicate flexibility and justice issues. A counterexample was the Norwegian householders emphasizing that they could see others having problems with fairness, but not so often themselves. Others saw fairness issues but brought them into unexpected areas strictly outside of energy demand, such as fire safety. Our study is one element of an ongoing and still vibrant discussion on the distributional impacts and fairness of energy transitions on this field site and which needs advancements in further research.

7. Conclusions

As part of energy transitions, electricity systems are currently being re-organized. A key element of this work is redistributing the costs that arise from transformation of energy systems. An expected development is that we will see new systems which reward and punish electricity consumption in terms of how ‘flexible’ it is. Typically, among energy policy makers, energy providers, and energy researchers, this redistribution is linked with economic rationality: the energy system is represented as fair when its tariffs reflect the ‘actual costs’ of flexibility. Those who do not adapt to this new system of flexibility will see the effects in their increased energy bills. However, when placed in the context of energy justice and fair energy transitions, the techniques promoting end-user flexibility are not necessarily neutral. The redistribution of costs for flexibility has unintended and unwanted social consequences. Those who have high flexibility capital are likely to be able to easily adapt to mechanisms and incentives promoting end-user flexibility. For those with little flexibility capital, the management of electricity consumption and flexibility work shapes their everyday life, so that activities, home and family live become marked by the time when they consume energy. Thus, the costs of doing flexibility work are not evenly and fairly distributed *between* and *within* different households. Consequently, energy justice initiatives addressing framings of end-user flexibility, including social equality and personal costs, would offer an important step to distribute the burden of flexibility work more evenly in society.

Our article focused on how the end-user flexibility is framed among end-users and systems developers. In this study, it became clear that the system developers and end-users were far from each other in these terms. Conceptualizations about users' willingness, abilities, moralities, and interests are shaped by divergent assumptions, knowledges, and resulting flexibility techniques, leading to difficulties in integrating frames that are often actually incompatible. As such, our article points to further research needs in transitions research and end-user flexibility. Flexibility is shaped by markedly different meaning-making and representations, which should receive more attention in flexibility development programmes for the future flexible electricity grid to be realized.

Acknowledgements

This work is funded by three sources blinded for review purposes. The authors gratefully acknowledge the funding from the Research Council of Norway through FME CINELDI - Centre for intelligent electricity distribution (grant number 257626) and FME NTRANS - Norwegian centre for energy transition strategies (grant number 296205); and the NTNU Energy Transition Initiative. Our gratitude also goes to the anonymous reviewers and the editorial team of EIST.

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