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The Envisioned Role of End Users in Future Electricity Systems

Doctoral thesis

NTNU
Norwegian University of Science and Technology
Thesis for the Degree of
Philosophiae Doctor
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Summary

Energy demand and everyday energy use has gained increased attention as an element of reducing carbon emissions and combating climate change. This doctoral thesis explores domestic electricity consumption and expert expectations for more flexible electricity consumption, also known as 'end-user flexibility', to reduce electricity demand peaks. The thesis is supported by four research papers that qualitatively study the role of end-users in the future energy system and end-user flexibility in various ways. Theoretically, the thesis draws on social science perspectives on energy, primarily from science and technology studies (STS).

Paper 1 identifies how expert actors in industry and researchers who work within smart energy developments envision solutions to encourage more flexible electricity consumption among end-users. Paper 2 deals with different framings of flexibility among traditional householders and experts and the potential social consequences of more flexible electricity consumption for the users. Paper 3 studies material, structural and social factors of students' electricity consumption and their understandings of flexible consumption, individually and collectively. Paper 4 focuses on rigid and flexible household consumption and studies changes in energy cultures in recent decades, and how these changes relate to increased demand for flexibility. Together, the papers highlight the role of electricity consumption in daily life, and how social life and societal structures enforce temporal rhythms that create peaks of electricity consumption.

The thesis questions the fundamental nature of end-user flexibility, and how this flexibility is currently shaped. It argues that implementing end-user flexibility can be viewed as an act of shifting responsibilities and work away from the energy system and towards the users. The discussions in this thesis emphasise energy justice issues and the elements of unpaid labour related to making electricity consumption more flexible. The thesis concludes that a more flexible electricity consumption may lead to a less flexible way of living, particularly for some social groups, such as vulnerable and untraditional end-users.

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When I told my then 10-year-old nephew that I got a PhD position, he enthusiastically asked me if I was going to be mixing exploding chemicals in a lab and grow bushy white hair. To his disappointment (and my relief) I had to tell him that that was not the case. Even though my hair has more than once looked Einstein-like and it has felt like my head was about to explode in frustration, this thesis is finally done. There are many people who have supported me along the way and made it possible for me to write this thesis. I owe you my deepest gratitude.

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Stavanger, May 2022

Ingvild Firman Fjellså

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1. Introduction: code red and people as part of energy systems

Rising sea levels, extreme weather, increasing global temperatures, and critical levels of greenhouse gasses in the atmosphere have pushed the Secretary-General of the United Nations, António Guterres, to declare 'code red for humanity' (United Nations, 2021, p. 1). Thus, transitioning toward low carbon societies and solutions is increasingly needed to reduce greenhouse gasses from burning fossil fuels and to curb climate change. The transport sector and the electricity and heat production sector are two of the largest contributors to global emissions and climate change (Solaymani, 2019) and thus important sectors to target in order to alleviate these challenges.

Most energy transition initiatives to date have revolved around reducing carbon emissions by means of efficiency measures and substitution of fossil energy sources with renewables. Currently, the initiatives are focused on developing and implementing carbon capture and storage (CCS), energy storage (e.g. batteries), and restoration and protection of nature, in addition to changing behaviour, practices, and encouraging sustainable choices (e.g. Grubler et al., 2018; SAPEA, 2021; Schwarzinger et al., 2019). However, it has been acknowledged that technologies alone will be insufficient to ensure a sustainable energy system. Energy demand and how people use energy need to be considered too (Mourik et al., 2017). This need is echoed by, for instance, the International Energy Agency (IEA, 2021a, p. 67), which states: 'It is ultimately people who drive demand for energy-related goods and services, and societal norms and personal choices will play a pivotal role in steering the energy system onto a sustainable path.' In recent years, there has been an increased attention in social sciences and humanities (SSH) research, approaches, and perspectives on energy problems. Nonetheless, these perspectives are still significantly underrepresented and overlooked in energy policy, when compared with insights from the disciplines within science, technology, engineering, and mathematics (STEM) (Foulds & Christensen, 2016; Ingeborgrud et al. 2020).

This thesis fits within social sciences and humanities, and the aim is to add to the increasing body of energy research conducted within SSH. I also seek to contribute perspectives that are relevant for energy policymakers, STEM scholars, and industry actors working with energy systems. In this thesis, which is positioned specifically within science and technology studies (STS), I adopt sociotechnical perspectives to gain a better understanding of the shaping of current energy systems, while focusing on the envisioned role of people in energy systems of the future. By underlining the energy system as a *sociotechnical system*, I aim to highlight that the energy system consists of elements beyond the purely technological and mechanical components, which often are foregrounded in discussions on future energy systems. The energy system also consists of elements such as people, cultural meaning, norms, laws, infrastructure, networks, and natural resources (Geels, 2005; Hess & Sovacool, 2020). STS perspectives are particularly suitable for this thesis because they focus on human and non-human actors, and the interconnected and reciprocal relationship between technology and society.

The thematic focus of the thesis is *flexible electricity consumption* among end users, which is also known as '*end-user flexibility*'. More specifically, in this thesis I study how consumers of electricity are expected to do so more flexibly in the future, how users envision changes in consumption will influence their daily lives, and how daily consumption is intertwined with norms, practices, material cultures, and external influences. I also consider potential unintended social consequences of end-user flexibility and I engage in discussion about energy justice.

The overall research questions that have guided the focus of this thesis are:

How is flexible electricity consumption shaped by expectations, energy culture, and everyday practices? What are the energy justice implications of end-user flexibility?

To answer these questions, I include four research papers that address end-user flexibility in various ways (Chapters 5–8) and present a cross-cutting analysis of the papers' collective contribution (Chapter 9). In the remaining part of this introduction (Chapter 1), I contextualize the topic of end-user flexibility by providing relevant background information on the current energy situation in Norway, and changes that have been made in the energy system to cater for increased electrification, including the challenges that arisen. In addition, I address the increasing demand for end users to participate actively in the energy system through more 'flexible' electricity consumption.

Hereafter, this thesis is organized as follows. Chapter 2 summarizes the research papers. Chapter 3 introduces theoretical perspectives and contains a review of previous studies of end-user flexibility that were fruitful for the development of the research questions and the overall analysis in the thesis. In Chapter 4, I present the details behind my methodological choices and my reflections. The four papers forming the main body of this thesis follow in Chapters 5, 6, 7, and 8, respectively. Chapter 9 synthesizes the overall findings of the thesis, building on findings reported in the papers and in light of theoretical perspectives. The conclusions are presented in Chapter 10.

1.1 The Norwegian context

In Norway, where the research for this thesis was conducted, energy production for national consumption has traditionally been dominated by hydropower, which provides relatively cheap and abundant electricity for households and industry alike. As Norway is both a hydropower nation and a large exporter of gas and oil, its public and private wealth have benefited (e.g. Hanson et al., 2011). Norwegian energy policies concerning electricity consumption have primarily been about energy economization (profitable energy efficiency measures) rather than energy reduction (Ryghaug & Sørensen, 2009; Sørensen, 2007). Concerns related to peaks of electricity consumption have received increased attention as strategies of electrification combined with variable energy production and increased integration with international energy markets poses challenges for the existing electricity grid. A political initiative to reduce potential issues relating to peaks in the grid has been to develop 'effect tariffs,' which are meant to give end users an economic incentive to reduce high levels of instant use of electricity (Meld. St. 36, 2020–2021). The planned implementation of new power tariffs have received moderate public attention in Norway, and the public debates have primarily involved politicians, academics, industry actors, and interest organizations. Despite the lack of a broad public debate concerning introduction of effect tariffs, the introduction might lead to unwanted consequences for electricity users. This thesis represents a contribution to the discussion by shedding light on the potential social consequences that concerns the role of end users in the future energy system in Norway.

The public debate and focus on energy consumption shifted during the winter of 2021/2022. The energy situation received extraordinary attention in Norway, due to reduced energy supply and a dramatic increase in electricity costs. Suddenly, the media were covering stories on a daily basis about people who could not afford the cost of electricity and were asking for donations (Nerbøberg, 2021), families who were living in the dark (Halleland & Tveit, 2021), and students who were avoiding heating their homes and going to the gym to shower (Hamre & Sællmann, 2021), in addition to a range of tips to save on electricity consumption and costs, including consuming electricity outside peak hours (i.e. at times when many others consume electricity and prices are high) (e.g. Hofstad & Holø, 2021). Injustices related to energy, such as energy poverty, have previously received little attention in Norway, unlike in many other European countries (Bredvold, 2020). However, recently injustices associated with energy access and costs has been a trending topic among the public and in policy, leading to a range of financial support schemes for people (Regjeringen.no, 2022). Additionally, sanctions against Russia due to the invasion of Ukraine in February 2022 have put extra pressure on energy access and caused oil and gas prices to rise in Europe (Khan, 2022).

The recent energy debates and events have illustrated the dependence and importance of affordable access to energy, and how difficult it can be to change or reduce energy consumption in daily life. As such, the current energy crisis in Norway and Europe has rendered the topic of this thesis actual, as the thesis deals with electricity consumption in households, flexibility, and issues related to energy justice. In the following subchapter, I turn to the topic of electrification.

1.2 Clean electrification

To reduce carbon emissions and combat climate change in line with the commitments made in accordance with the Paris Agreement (2015), the electricity sector in Norway, among many other sectors, such as transport, ICT (information and communications technology), and agriculture, is undergoing fundamental changes. A key element of the ongoing transition is to increase the use of renewable energy sources in order to substitute the use of fossil fuels in the production of electricity (Markard, 2018). Decarbonization of the electricity sector is considered crucial, as it is anticipated that other sectors will depend on electrification for decarbonization (Eyre et al., 2018). The International Energy Agency (IEA, 2021b) highlights that 'a massive additional push for clean electrification', is one of four priority measures to keep the door to 1.5 °C open in the scenario of net zero emissions (NZE) by 2050 scenario. The importance of clean electrification is also echoed among other actors, such as the Science Advice for Policy by European Academies (SAPEA, 2021), and the European Commission's Joint Research Centre (Keramidas et al., 2020). In Norway, where hydropower accounts for a large share of the electricity mix, it is stated that to a large extent climate policies are about electrification, meaning replacing fossil fuels with electrical energy (Verlo et al., 2020). Reducing carbon emissions from the transport sector, industries on land, and the petroleum sector is considered important in the national context, as the three sectors produce a large share of the Norwegian emissions (Haukeli et al., 2020).

Even though variable renewables, such as solar panels and wind power are being deployed at a rapid rate to produce low-carbon electricity worldwide (REN21, 2019), the introduction of variable energy sources in the energy system poses some challenges. One such issue is the balance between supply and demand: 'With large shares of variable and distributed electricity generation, the balance between supply and demand that is needed to keep power systems functional can (in most places) no longer be kept the way it has been, without inducing unwanted emissions' (Öhrlund, 2020, p. 12). When fossil fuel based power plants are used to balance the energy system, a positive correlation between demand and carbon emissions is created in the production of electricity, but this is not necessarily the case when using, for example hydropower as a balancing power (Stoll et al., 2014).

A further issue with increased electrification and the use of variable energy sources is the lack of synchronization between peaks in demand and the production of electricity from weather-dependent sources (Öhrlund, 2020). Peaks in demand are linked to the temporal rhythm in society and often occur in the morning and afternoon when people either leave for or return from school and work, but they also follow seasonal variations (warm/cold temperatures), and special occasions such as Christmas and New Year's Eve (Blue et al. 2020). Also, electrification of the transport sector, among other sectors, creates local peaks (Ilieva & Bremdal, 2021). Peaks are expected to rise due to increased electricity demand and access to new energy demanding technologies (Sæle, 2020), and they may pose an issue even in countries with large hydropower resources (Torriti, 2015). Energy demand is not necessarily attuned to windy conditions, when wind turbines generate electricity, or when the sun is shining on solar panels. Additionally, higher peaks in demand and supply may create issues in terms of grid capacity shortages and they may influence the volatility of electricity prices (Dong et al., 2019). Some of the issues can be dealt with by reinforcing the physical grid infrastructure. However, that can take a long time and does not solve the issue with balance, and thus in many cases it is not considered a cost-efficient solution (Öhrlund, 2020; Sæle, 2020; Ilieva & Bremdal, 2021).

1.3 Smart grid, smart meters, and end-user flexibility

A promising alternative to the existing grid infrastructure that emerged in the early 2000s is a more intelligent grid – a 'smart grid' (Slayton, 2013) – that could improve the energy system by using digital information and communications technologies (Verbong et al., 2013). The European Commission's policy for Trans-European Networks for Energy Regulation defines smart grids as follows:

> an electricity network that can integrate in a cost efficient manner the behaviour and actions of all users connected to it, including generators, consumers and those that both generate and consume, in order to ensure an economically efficient and sustainable power system with low losses and high levels of quality, security of supply and safety. (Regulation (EU) No 347/2013)

A key component of the policy has been the installation of smart meters around the globe. In the EU, 50% of electricity meters have been replaced with smart meters (Nhede, 2021), and in Norway, the rate is 97% (Viseth, 2019). Smart meters enable hourly, automatic, and more accurate metering, lower response time for localization and correcting power outages, and increased security of supply (NVE-RME, 2021). Embedded in smart grids and meters there are also expectations that information about hourly electricity consumption will provide electricity consumers with an incentive to reduce or shift their consumption to times when electricity prices and demand are lower (Ballo, 2015; Bulkeley et al., 2016; Hargreaves et al., 2013; Sovacool et al., 2017a).

While traditional grids are primarily for energy transmission, smart grids have for some time been expected to change the relationship between production and peoples' consumption (Skjølsvold et al., 2015). As such, users of energy have traditionally been treated as passive market actors in the margins of a centralized system, but they are increasingly expected to take more active roles in the future, for example as consumers, prosumers, or energy citizens (Olkkonen et al., 2017; Parag & Sovacool, 2016; Ryghaug et al. 2018; Wesche & Dütschke, 2021). Active involvement of users in smart grids is often seen as a key to success and is often reflected in descriptions of users as potential 'co-providers', 'empowered users', or similar, to emphasize users' importance (van Mierlo, 2019; Van Vliet et al., 2005). One way that is desirable for energy users to take on more active roles is by engaging with the energy system through a more 'flexible' electricity consumption, also termed 'end-user flexibility', by reducing or shifting their consumption of electricity away from times when demand is high and the power grid is strained (Friis & Christensen, 2016; Parrish et al., 2020; Torriti & Yunusov, 2020).

The notion of using end-users' flexibility potential to reduce pressure on the electricity grid has received increased attention among policymakers and industry actors over the last decade (Ballo, 2015; M. A. Brown et al., 2018; Sareen, 2020). Incentivizing electricity users to be more sensitive to the grid, and thus reduce consumption at peak hours by 'shifting' (moving consumption) or 'shaving' (avoiding consumption) is considered an attractive alternative to grid investments in terms of saving costs and catering for increased electrification across sectors (e.g. Lien et al., 2020; Pfeiffer et al., 2021). Policies aimed at incentivizing users to become active as consumers have primarily centred on price signals and information (e.g. Ryghaug et al., 2018). For example, the objective of demand side management (DSM) has been to influence electricity users to fit with the need of energy utilities and the energy system in a better way (Palensky & Dietrich, 2011). The Norwegian Energy Regulatory Authority, NVE-RME, states that for the power grid, end-user flexibility means that consumers of electricity have the possibility and willingness to change electricity consumption based on the situation in the grid, and that consumption can be reduced when the strain on the grid is high and increase when the strain is low.

It is evident that there are high expectations from industry actors and policymakers to use end-users' flexibility potential to reduce consumption at peak load hours, and it seems that this will become even more important in the future. However, there is still much we do not know in terms of how end-user flexibility will unfold in the future, particularly regarding the role of users, and the social costs and consequences. In this thesis, I do not strive to foresee the future, but I aim to provide perspectives on end-user flexibility that will add to the scholarly body of knowledge about future energy systems, the role of users, and flexible electricity consumption, which may be constructive in future processes of development in flexibility incentives and mechanisms.

Before presenting a summary of the four research papers that constitute the main part of this thesis, I wish to clarify the use of the term 'end-user flexibility'. The empirical attention in this thesis is primarily directed at flexibility, electricity use, and users[1], and therefore the term end-user flexibility is used to emphasize this attention. The term is used when referring to end users' changing electricity consumption by either avoiding the use of electricity at certain times (peak hours) or moving it to other times of the day or week (away from peak hours). The notion of changing energy demand to fit the needs in the grid is often referred to as demand side response (DSR) (e.g. Daryanian et al., 1989) or demand side management (DSM) (e.g. Strbac, 2008). Also, terms, such as demand side flexibility (e.g. Söder et al., 2018) or domestic demand response (e.g. Hamidi et al., 2009) are used to with reference to changes in energy demand. To date, in much of the research conducted on flexible electricity consumption and users, the focus has been on the technical or economic aspects. However, in this thesis, the focus is on the sociotechnical aspects.

[1] The terms 'user' and 'end user' refer to private consumers of electricity. In other cases, they may refer to businesses or other sectors that use electricity. However, in this thesis it refers to householders.

2. Summary of Papers 1–4

In this chapter I present a summary of the four research papers that constitute the main empirical work for this thesis. The papers deal with the role of users in the energy system and end-user flexibility in various ways, and they draw on social science perspectives on energy, mainly inspired by perspectives that build upon science and technology studies (STS). The details of Papers 1–4 are listed in Table 1. Paper 1 looks at experts' expectations concerning solutions to encourage more flexible electricity consumption among end users. Paper 2 deals with different framings of flexibility among traditional householders and experts, in addition to the potential consequences of more flexible electricity consumption for the users. Paper 3 studies students' electricity consumption and their understandings of flexible consumption, individually and collectively. Paper 4 focuses on rigid and flexible household consumption, and studies changes in energy cultures in recent decades and how these changes relate to increased demands for flexibility. In the cross-cutting analysis in Chapter 9, I provide a comprehensive analysis of what readers can draw from the research papers collectively.

Table 1: Overview of the research papers

Paper	**Title**	**Authors**	**Publication status**
1	'Det fleksible mennesket 2.0: Om sosiale relasjoner i fremtidens digitale elektrisitetssystem'[2]	Skjølsvold, Fjellså and Ryghaug	*Norsk Sosiologisk Tidsskrift*, 2019
2	'Justice aspects of flexible household electricity consumption in future smart energy system'	Fjellså, Silvast and Skjølsvold	*Environmental Innovation and Societal Transitions*, 2021
3	'Flexibility poverty: "Locked-in" flexibility practices and electricity use among students'	Fjellså, Ryghaug and Skjølsvold	*Energy Sources, Part B: Economics, Planning, and Policy*, 2021
4	'Flexible energy cultures? How accelerated energy transitions and flexibility needs affect the understanding of energy consumption amongst Norwegian households'	Fjellså and Skjølsvold	*Submitted*

[2] The paper is written in the Norwegian language. The title translates into English as "Human flexibility 2.0 – on social relations in the digital electricity system of the future."

2.1 Paper 1: 'Det fleksible mennesket 2.0: Om sosiale relasjoner i fremtidens digitale elektrisitetssystem'

The paper is published in a special issue of the *Norwegian Journal of Sociology* on digitalization. It seeks to introduce discussions about digitalization of the electricity grid to a Norwegian audience of sociologists. The paper analyses system developers and researchers' expectations and visions for 'end-user flexibility', and it draws empirically on qualitative interviews with central actors working to digitalize and modernize the power grid, and theoretically on sociology and STS literature.

The point of departure for Paper 1 is challenges in the electricity grid due to peak loads. From an electricity grid perspective, too much electricity is consumed at the same time, and therefore daily electricity consumption and daily life have become a matter of politics through the notion of end-user flexibility. The paper has a three-fold focus: (1) how problems with the current electricity distribution grid are presented, and expectations of grid digitalization, (2) expectations toward consumers regarding 'end-user flexibility', and (3) which technologies, forms of organization, and price mechanisms are envisioned, and how these are expected to work.

The findings presented in Paper 1 suggest that electricity consumers were understood by experts as generally being uninformed and disinterested, but also economically rational. Experts translated this into a set of social, economic, and technical solutions, which were envisioned to transform and activate passive consumers. Three ideal typical solutions were identified as the most promising to incentivize users to consume less electricity during peak load hours. The first solution concerned information tools, such as information campaigns and digital visual feedback systems, to increase knowledge and change attitudes. Second, economic tools, such as the planned introduction of effect tariffs, were expected to economically stimulate active profit maximizing choices. Third, technical solutions to delegate energy choices either to professional third parties (e.g. aggregators) or to automation were envisioned to achieve end-user flexibility with little direct involvement from the consumers. The analysis points to expectations that digitalization of the grid could produce a new form of electricity consumer, who can offer their flexibility as a commodity to grid companies, either through reduced consumption or through non-consumption. It also suggests that digitalization is expected to assist in the transformation of electricity consumption through unnoticeable and neutral means. Paper 1 problematizes the notion of flexibility by implicitly drawing parallels to Richard Sennett's book *The corrosion of character* (Sennett, 1998), suggesting that people's flexibility and ability to adapt to the market becomes a commodity, as seen in labour markets.

2.2. Paper 2: 'Justice aspects of flexible household electricity consumption in future smart energy system'

Paper 2 is published in *Environmental Innovation and Societal Transitions*' and engages with the energy transitions and energy justice literature. It studies end-user flexibility from the perspectives of both users (traditional householders) and experts in order to examine similarities and differences in understandings of flexibility and the proposed solutions (identified in Paper 1). The paper discusses (1) how the transition toward increasing flexibility in electricity distribution affects electricity users in terms of energy justice and fairness, (2) how technology developers and users frame flexibility, and (3) the implications of the difference between technology developers' and users' framings have for sustainable energy transitions.

The findings suggest that the householders varied in terms of their willingness and capacity to be flexible, and that there was a discrepancy between experts' and users' expectations toward end users. The users challenged the experts' assumptions of users as disinterested and uninformed economically rational agents. The householders demonstrated interest in flexibility issues and expressed reasons that went beyond economic interests. Reasons framed as acting in solidarity with the environment, the local community, or society in general were considered valid reasons for engaging in flexibility work. Many of the householders did not seek to be compensated economically for what they saw as a common good. However, they did not like the idea of the energy industry gaining economic profit from their efforts. The householders also saw some practical aspects as problematic in terms of shifting or reducing electricity consumption in daily life.

Paper 2 identifies different ways of doing ‘flexibility work’ in households, either through manual work (shifting or reducing electricity consuming activities) or by using “smart’ systems available in the household, or by making investments in such systems, or outsourcing the work. The findings were used to develop the energy justice theory further by linking options for engaging in flexibility work to flexibility capital (Powells & Fell, 2019). Paper 2 emphasizes the importance of addressing energy justice and fairness aspects in the promotion of end-user flexibility and energy transition processes.

2.3 Paper 3: ‘Flexibility poverty: “Locked-in” flexibility practices and electricity use among students’

Paper 3 is published the special issue titled ‘New Energy Downstream. Emerging business models and innovative best practices: an economic, institutional and behavioural focus’ in the journal *Energy Sources, Part B: Economics, Planning and Policy*.’ The paper introduces narratives from an ‘untraditional’ group of electricity users who are considered to be ‘free and flexible’, namely students. The empirical material is based on written narratives and illustrations of energy-related activities in daily life, from Norwegian students. Daily activities (showering, laundry, and the use of ICT) were studied, and the paper discusses how individual’s energy-related activities were often perceived as flexible, but collectively the students’ flexibility potential became ‘locked-in’ due to socio-material factors, such as their life situation, housing, and limited flexibility capital. Thus, the students’ inflexibility stood out, not primarily as individual choices, but rather as limited by societal temporal rhythms and materiality, in line with previous findings (e.g. Shove, 2003; Walker, 2014).

Paper 3 draws on the concept of ‘lock-ins’ (Arthur, 1994; Unruh, 2000) and suggests that flexible electricity consumption can be understood as breaking existing patterns of electricity consumption. However, the paper argues that a path with a narrow focus and strong flexibility incentives might paradoxically lead to less flexibility in daily life, particularly for social groups in untraditional life or living situations. ‘Flexibility poverty’ is proposed as a term to describe how some people have limited capital, capacity, time, and space to act on their flexibility potential, and hence have fewer alternatives for engaging in flexibility work. The paper emphasizes the inclusion of alternative narratives to broaden the understandings of electricity consumption and end-user flexibility, and the effects of social, structural, and material factors. The paper calls for energy flexibility regulators to consider the importance of distributional bias in public support for energy efficiency measures, as householders in untraditional life or living situations often fall outside the scope of such support schemes, which make them more vulnerable to flexibility poverty and energy poverty.

2.4 Paper 4: 'Flexible energy cultures? How accelerated energy transitions and flexibility needs affect the understanding of energy consumption amongst Norwegian households'

Drawing on energy cultures literature (Aune, 1998; Aune et al., 2016; Stephenson et al., 2010; Stephenson et al., 2015), Paper 4 studies how norms, practices, material culture, and external influences affect householders' electricity consumption and flexibility. The paper focuses on traditional householders' daily energy-related activities and technologies, and it identifies the rigidity and flexibility in terms of the householders' potential to reduce or shift energy-related activities to other times. The findings show that time-dependent activities such as cooking, and 'background technologies' such as fridges, were considered hard to change, while less frequent activities, such as cleaning, were easier to change. Even though some activities were considered somewhat easy to change, such as washing clothes, further examination revealed how the flexibility was restrained and intertwined in the energy culture through norms, material culture, practices, and external influences, such as house rules, logistics of work schedules and family life, and safety assessments. The paper argues that the users' flexibility potential was influenced by reasons beyond individual willingness and personal choices. The analysis revealed that most householders had taken steps to reduce electricity consumption and only used electricity when they considered it necessary, and therefore considered their potential to reduce or change consumption was limited without drastically rearranging their daily life schedules or making larger investments in energy efficiency in the home.

The findings are discussed in a historical context, drawing on Norwegian energy consumption trends and energy culture (Aune, 1998; Aune et al., 2016), and they suggest a shift in energy culture from electricity being perceived as abundant and clean in the 1990s, toward concerned consumption in the 2000s, to conscientious consumption in the late 2010s, whereby most users would be categorized as having a 'sparse' energy culture (Aune, 1998). Paper 4 urges those who work with technologies and solutions aimed at end users to consider how and in what way end-user flexibility solutions will influence norms, practices, material culture, and external influences in the future.

3. Theoretical perspectives and previous research on users and smart technologies

The thesis deals with expectations with regard to users, electricity consumption and flexibility, and energy justice. In this chapter I examine in more depth the theoretical frameworks within STS that are suitable for addressing these topics. STS provides useful sociotechnical perspectives to explore 'black boxes' (Latour, 1987), meaning that STS in many ways seek to examine what has often been taken for granted and aspects that are considered matters of fact concerning technology innovation, social developments, and knowledge production. STS offer perspectives on 'interconnections, mutual shaping, co-constitution, or coproduction of the technical, social, and natural' (Hess & Sovacool, 2020, p. 2).

This theory chapter consists of three parts. The first part introduces theoretical perspectives related to *expectations* regarding future technology users. The second part deals with technology and energy *use and users*. The third part presents *energy justice* literature. Most of the theories presented in this chapter are used in Papers 1–4. Some of them are only mentioned rather briefly in the papers, and therefore I elaborate more on them here. Additionally, I discuss domestication theory, which is not directly used in any of the papers but is a very useful theory for discussing the overall contribution of the papers as discussed in the cross-cutting analysis. Throughout this chapter, I also refer to previous studies of energy consumption and flexibility relating to the topics of expectations, use and users, and energy justice.

3.1 Expectations regarding future technology users

There have been long traditions of social science scholars studying expectations and visions of the future, in addition to their implications. Almost one hundred years ago, Dorothy Swaine Thomas and William Isaac Thomas formulated a simple but influential sentence, which is coined the 'Thomas Theorem': 'If men define situations as real, they are real in their consequences' (Thomas & Thomas, 1928, p. 572). In other words, expecting certain futures will have real implications in the form of consequences, and thus for the future. Within STS, scholars have been particularly interested in relationships between users and designers, including the role of visions or imaginaries in processes of technology developments (Ryghaug & Toftaker, 2016; Skjølsvold & Lindkvist, 2015). Borup et al. (2006, p. 285) state:

> innovation in contemporary science and technology is an intensely future-oriented business with an emphasis on the creation of new opportunities and capabilities. Novel technologies and fundamental changes in scientific principle do not substantively pre-exist themselves, except and only in terms of the imaginings, expectations and visions that have shaped their potential. As such, future-oriented abstractions are among the most important objects of enquiry for scholars and analysts of innovation.

Studying expectations provides an opportunity to examine the rationale behind incentives, systems, and technology developments, such as smart grids and flexible energy systems, in addition to expectations about human values, motivation, and abilities. I next look at both Akrich's and Woolgar's conceptualizations of technologies as bearers of expectations, as this is relevant to my study of designers' assumptions about users concerning developments in flexibility incentives and mechanisms.

3.1.1 Script and user configurations

Akrich (1987, 1992) suggests that all technological artefacts are bearers of 'scripts' and 'scenarios' that are intended to direct their use. In this view, scripts are produced in the design and developing process of technologies, reflecting designers and developers' expectations of how future users will handle and interact with the technologies. Thus, the scripts bear the developers' expectations about users' interests, motives, competence, and limitations, which are materialized in the technologies. Akrich (1992, p. 208) states:

> Designers thus define actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science, and economy will evolve in particular ways. A large part of the work of innovators is that of "inscribing' this vision of (or prediction about) the world in the technical content of the new object.

In common with Akrich, Woolgar (1990) turned to literature theory and suggested that machines and technologies could be studied as texts. This was not to claim that machines are text, but to explore the relationship between the writer (designer) who constructs a text (machine) and its readers (users) who interprets and engages with the texts. Woolgar uses the metaphor of machines as text, suggesting that machines are developed to have certain thoughts about users' capacities and characteristics. Thus, what is 'written' into the machine or technology, and how the users interact with the machine, is formed by how the users are configured. In this thesis, developers are seen as 'authors' who contribute to writing and thus scripting end-user flexibility technologies and incentives. Building on such theoretical perspective has allowed me to study which solutions are expected to be successful in encouraging flexible consumption among electricity users.

The relationship between users and machines or technologies is dependent on the context of the use situation, which is defined by the social relations of the artefact is made up (e.g. Lie & Sørensen, 1996; Pinch & Bijker, 1984; Woolgar, 1990). Woolgar (1990) claims that how a machine is used involves 'boundary work', which means that designers configure users, who through the artefacts set boundaries for the machine's use, and that the more significant the boundaries are, the more likely inappropriate behaviour is to be prevented: 'Insiders know the machine, whereas users have a configured relationship to it, such that only certain forms of access/use are encouraged' (Woolgar, 1990, p. 89). In the cross-cutting analysis, I argue that, like technologies, flexibility incentives are holders of scripts, and that these incentives are bearers of boundaries. I claim that the boundaries of flexibility incentives for electricity users have a more prominent differentiation when in effect. Thus, some users can choose to ignore the boundaries inscribed in the flexibility incentives, while others cannot ignore them.

The notion of technologies as holders of scripts and boundaries provides a lens through which to study flexibility solutions as bearers of assumptions about users' motivations and abilities. In this way, it provides a lens through which to unpack how knowledge is constructed and how, for example, technologies are made up of more than purely mechanical components, such as politics, values, and moral. When users act differently than anticipated by designers, it is often explained by users lacking knowledge, which is referred to as 'knowledge deficit'.

3.1.2 User expectations: the knowledge deficit model

Woolgar's narration of a typical expert view, points to the relationship between experts and lay people, suggesting that users are often viewed as problematic if behaving differently than anticipated: 'Users can't help the way they behave; they just need to be educated to understand what we are trying to achieve here. Readers can't help the way they interpret the text; they just need to be educated' (Woolgar 1990, pp. 89–90). Rather than the technology itself or its creators having any shortcomings or deficits, Woolgar claims that users need more knowledge to ensure that they use technology correctly. In my case, this distinction is useful, as the perspective provides me with a lens through which to study experts' expectations about users' knowledge and motivations for flexible electricity consumption. How technologies are used in unintended ways by users has been explained by STS scholars through, for example, domestication theory (e.g. Lie & Sørensen, 1996; Silverstone et al., 1992), which I discuss in Subchapter 3.2.1.

Studies of relationships between lay people and experts suggest that experts tend to apply a 'knowledge deficit model' (e.g. Barnett et al., 2012; Maranta et al., 2003; Skjølsvold & Lindkvist, 2015; Walker et al., 2010). The knowledge deficit model portrays members of the public as lacking morals or knowledge with regard to a particular issue. Often, such deficit is used to explain that an issue may be too difficult to understand and that this causes the public to resist certain projects or technologies (Karlstrøm & Ryghaug 2014; Miller 2001; Ryghaug et al., 2011; Ryghaug et al., 2018). For example, assumptions about public resistance toward wind technology are incorporated into the design and development processes to avoid potential protests (Heidenreich, 2015). Thus, members of the public are often considered a problem to be defeated, which is often thought best to be solved through solutions, such as clever design tactics or technocratic strategies (Ryghaug & Toftaker, 2016; Skjølsvold & Lindkvist, 2015). Such framings are also seen in the smart grid field, where users are viewed as lacking knowledge and engagement, and technologies are viewed as solutions to assist users to achieve flexible consumption.

Framing response from the public in terms of knowledge deficits has been systematically criticized by STS and ethnographic scholars (e.g. Burningham et al., 2015; Wynne, 1991).

According to Wynne (1991, p. 116), ‘public uptake (or not) of science is not based on intellectual capability as much as socio-institutional factors having to do with social access, trust and negotiation as opposed to imposed authority’, which underpins the importance of looking beyond intellect or knowledge when trying to understand why some public understandings are in line (or not) with that of science or policy. I consider this perspective important when it comes to flexible electricity consumption, as electricity is highly intertwined in daily life, and therefore changes in electricity consumption may affect many areas of domestic life. To understand why such changes are hard to achieve, they must be studied from various perspectives, including perspectives that look beyond individual willingness or lack of knowledge. STS and other social sciences have emphasized the importance of, for instance, public engagements and energy citizenship (Ryghaug et al., 2018) or other means of sense-making (Ryghaug et al., 2011), when it comes to understanding how climate change are made sense of and the role of the public in low-carbon energy transitions.

It is important to understand expectations in terms of how people are expected to use and relate to technologies, and how this in turn contributes to the construction and shaping of technology and societal developments. Such expectations make the concepts of imagined publics and sociology of expectations relevant for this thesis.

3.1.3 Sociology of expectations and imagined publics

The literature on the sociology of expectations (Borup et al., 2006; Van Lente, 2012) and imagined publics (Maranta et al., 2003; Walker et al., 2010) has demonstrated how expectations about the future and members of the public become performative through action strategies that are shaped by expectations. These expectations concern technology developments and assumptions about their effect and influence, in addition to expectations of human rationality and how this influences interactions between new technologies, users, and daily practices. Together, imagined publics and the sociology of expectations are useful as a lens through which to study experts’ expectations towards the future, and in the case of this thesis, expectations about the future of energy systems and the role of people.

Concerning the sociology of expectations in 'foresight exercises', whereby stakeholders carve out potential futures for socio-technological developments, Van Lente (2012) suggest that three lessons can be learned. First, with regard to expectations about the future build of preexisting assumptions, and thus drawing on existing repertoires, by building on preexisting assumptions that occur in a 'sea of expectations', expectations may reinforce existing paths and contribute to lock-ins (Jacobsson & Johnson, 2000; Unruh, 2000). One example is the assumption that individualized economic incentives will work to reduce energy demand because they might have done so in the past. Second, statements about the future have power in the sense that they are not neutral descriptions but are performative and can be used to support assumptions, positions, and claims. Networks that are built on foresight exercises will adopt and promote the claims they make: 'Once they are voiced and circulated, they will legitimise, steer and coordinate efforts, also for unintended purposes' (Van Lente 2012, p. 778). For stakeholders, at a distance from the knowledge production, possibilities may appear as facts, without insight into details and uncertainties. One example would be to develop an energy system for the future based on the assumption that it is possible to achieve end-user flexibility. The third lesson suggests that developments build on preexisting expectations, where stakeholders may anticipate certain expectations and adjust to them. According to Van Lente (2012), stakeholders' visions may become self-fulfilling, and their visions may have unintended consequences. The three lessons are useful when studying experts in smart grid networks and their expectations about the future of end-user flexibility, when (it is expected) that it will be possible to pursue certain paths and solutions, for example to achieve flexibility outside the electricity grid.

While the strand of sociology of expectations studies how certain versions of the future can be maintained and narrated to give direction to innovation projects, the literature of imagined publics, through for example 'imagined lay persons' (Maranta et al., 2003) studies how experts try to make scientific knowledge socially robust (Throndsen, 2017).

Maranta et al. (2003) suggested that there is a 'epistemic divide' between lay people and experts, where experts and lay people live in different worlds in terms of viewing the world differently. Furthermore, Maranta et al. (2003) claim that this difference in world views need to be considered if experts want to assist lay people in their actions. Experts must anticipate what others may find relevant, as this might affect what is assumed to be possible. Thus, experts must deal with a dilemma: they must preserve the epistemic symmetry, while they still have to formulate advice that will be understandable to lay people: 'Thus, feasible advice has to bridge the epistemic gap between experts and lay persons. In order to span this gap successfully, experts need to establish credibility and trust' (Maranta et al., 2003, p. 151). Hence, experts must uphold but also bridge the epistemic gap by building trust and creditability, while at the same time anticipating reactions from the public. In this thesis the divide between experts and lay people is visible in Papers 1 and 2, where the first paper studies how experts anticipate that users will respond to certain flexibility incentives and mechanisms, and the second paper includes electricity users' responses. The two papers show a clear divide between users of electricity and experts' assumptions about users' possibilities to consume electricity more flexibly.

How users are configured and expected to respond to certain mechanism or incentives influences the process of scripting, as it draw on designers' expectations with regard to users' capabilities and motivations for change. For example, expecting electricity users to be economically rational will influence how policies are formulated and how technologies or incentives are developed and implemented to fit such expectations. Thus, it is important to study expectations, so that it will be possible to identify where expectations come from, what knowledge they build on, and how they are reproduced in networks, and to address the impacts they may have for the future and future users, through, for instance, technology design and developments, policymaking, and research priority areas. In this thesis, I address experts' expectations concerning flexible electricity consumption among users and discuss them in relation to energy justice. I argue that expectations have important justice implications that need to be addressed to achieve flexibility in a just way.

3.1.4 Previous studies of expectations for flexible energy consumption

STS scholars have deployed theoretical frameworks and perspectives such as those outlined in the preceding subchapters (3.1.1 - 3.1.3) to study expectations regarding flexible electricity consumption, smart grid developments, and technologies. For instance, Ballo (2015) studied collective visions of the future smart grid and smart meters in Norway. Her findings suggested that the performative smart grid imaginaries were mainly technological and economical. Discussions about the future smart grid development were to a large extent held within a national network of experts', without much public debate. This finding suggested a gap between what was being communicated to the public and the network's imaginaries regarding future smart grid development. Consumers were constructed as economic actors with engagement and knowledge deficits, thus communication to the public strongly emphasized the benefits of smart grid and smart meters, but uncertainties and potential social implications were excluded. Ballo (2015) also points to a tension between the network's emphasis on the security of supply as a public good, and the privacy rights and autonomy of individuals, where the security of supply trumped privacy rights and autonomy. She found that potential social implications, including environmental perspectives, financial consequences for vulnerable households and their security were not adequately addressed and had partly been reduced to a technical issue. Thus, based on her study of visions of Norwegian smart grids, Ballo (2015) called for increased transparency and the inclusion of multiple perspectives in future smart grid developments.

Perceptions of users as economic actors with typical knowledge deficit characterizations have been found in various studies exploring experts' expectations regarding smart grids and their (future) users. For instance, in a set of eleven Danish smart grid projects, Hansen and Borup (2018) identified three dominating scripts: an economic script, an automation script, and an information/visualization script. Earlier, Throndsen (2017) had reached a similar conclusion when reviewing a large group of research papers on smart grids. Throndsen (2017) found that experts' narratives of smart grid were dominated by three characteristics: (1) economic rationalization, seeking to facilitate user rationality by using economic incentives, (2) seeking to bypass users technologically through autonomation of energy consumption, and (3) social science critique involving comparison of imagined users and 'real' users. Schick and Gad (2015) found that the national smart grid network visions in Denmark relied on techno-centric and inflexible consumer figurations, from document analysis and interviews concerning how future 'flexible electricity consumers' were imagined in Denmark's national Smart Grid Strategy. However, when analysing the empirical material with reference to notions of 'infra-critique' (Verran, 2014) and 'infra-reflexivity' (Latour, 1988), Schick and Gad (2015) found various and contradictory understandings of consumers within the smart grid network and their strategy documents, suggesting the presence of modes of reflexivity and critique within the field.

In a study of how smart grid development projects represent the 'user' of smart grid and smart metering technologies, Silvast et al. (2018) found that European technology developers and experts expected that users would become more active, in different ways, in the future. Users were expected to be motivated by the use of smart technologies to save money and energy, or 'even [by] becoming a more active participant in energy provision altogether' (Silvast et al., 2018, p. 15). The authors point to important aspects of preconfigurations of 'users', which varied from *smart meter users* to *smart infrastructure users*. In some cases, users were expected to engage with existing smart metering solutions, and in other cases to engage with smart systems and services of the future. Thus, Silvast et al. (2018) point out the need for further technology and service development, particularly if the envisioned user profiles appear unrealistic for currently available technologies. They also point out the importance of following up on descriptions of users periodically, as developments evolve and smart technologies mature.

To summarize the above-discussed literature, similar framings and constructions about users can be identified in studies of experts on smart grid networks, suggesting a set of dominating views among such actors and networks. This has pushed scholars to advocate the need to include a broader set of perspectives, and transparency in processes (Ballo, 2015). There is a need for clarification of who are the envisioned users and what they use (e.g. smart meters or smart infrastructures) (Silvast et al., 2018), and such clarification must also include a more flexible approach to the relations between technical and social aspects in energy studies (Schick & Gad, 2015). Hence, continuously following experts' expectations toward users of smart grids and the implementation of flexibility incentives or technologies is important in order to identify developments and potential changes that will affect the energy system and users. This thesis studies such visions and expectations from experts in a Norwegian context, in addition to users' expectations regarding more flexible consumption of electricity in daily life. This has made it possible to 'test' empirically some of the experts' expectations about potential future user in their domestic everyday context, and thus shed light on the variations in expectations from various sites in the energy systems infrastructure. In the next subchapter I turn to electricity use and domestication theory, which is a fruitful theoretical perspective in order to gain a better understanding of the reciprocal relationship between technology development, implementation, and user practices.

3.2 From design to use and users

In this thesis, I study the flexibility of energy-related technologies and activities in households by examining how electricity consumption and flexibility are experienced and understood in daily life, and how this in turn relates to wider societal contexts. It has been noted in energy research from the social sciences and humanities that there has been a move away from a focus on individual behaviour and behavioural change toward sociological understandings and plural understandings of energy issues (Ingeborgrud et al. 2020; Mourik et al., 2017). Various practice approaches and frameworks rooted in the sociology as a discipline have been developed (e.g. Gnoth, 2013; Shove & Walker, 2014; Jensen et al., 2011), and together they highlight the interplay of technology, material culture, norms, values, institutions, and other factors in energy practices (Mourik et al., 2017). Thus, the practice approaches emphasize that energy use is interlocked in various daily practices, such as cooking, cleaning, and keeping comfortable, which require energy, and that energy use itself is something users rarely consciously engage with (Ingeborgrud et al., 2020). In this perspective, considering how practices are socially organized, how they evolve over time, and how they are reproduced in society may foster a better understanding of how practices can be changed (Buchmann et al., 2017).

One example of how practices can be changed is through the development of 'energy cultures' studies (Aune, 1998; Stephenson et al. 2010, Stephenson et al., 2015). Inspired by, and building on cultural sociology (e.g. Bourdieu, 1992), structuration theory (Giddens, 1984), social practice theory (Shove, 2003), actor-network theory (e.g. Latour, 1993), Stephenson et al. (2010) and Stephenson et al. (2015) have established a comprehensive energy cultures framework for analysing energy consumption and energy efficiency in households. They suggest that by studying norms, material culture, practices, and external influences related to energy, it is possible to identify what shapes an energy culture. An energy culture can be a single household, a neighbourhood, region, nation, or something else. The elements in an energy culture influence each other, and therefore only looking at, for example, norms or material culture will not be sufficient when trying to understand why and how energy is consumed in a particular way.

A more comprehensive introduction to the energy cultures literature is presented in Paper 4, where it is used to study Norwegian energy cultures and how they have developed since the 1990s. In the cross-cutting analysis (in Chapter 9), I use the energy cultures framework in combination with domestication theory to discuss what changes in electricity consumption might entail for householders. I also discuss these aspects in relation to a wider context concerning the social costs and consequences of flexible consumption in the form of energy justice issues.

3.2.1 Domestication

> In everyday settings, we consume technologies – or, more precisely, technical artifacts – by integrating and using them. We are also consumed by the artefacts when they gain our attention and have us react to them and become occupied by their abilities, function, and forms (Lie & Sørensen, 1996, p. 8)

As I have shown thus far in this thesis, when technologies leave the hands of their creators and are placed with the user, their use is not always in line with what the creators expected. When technologies are being taken into use, it will happen as an ongoing process, which some scholars within STS have coined 'domestication' (e.g. Lie & Sørensen, 1996). However, the term was first introduced by media scholars Silverstone et al. in the early 1990s (e.g. Silverstone et al., 1992), when it was used as a metaphor to describe what happened when ICTs were introduced into households. The word 'domestication' draws on the notion of what happens when wild animals are transferred from their natural habitat, tamed, and brought into households, for example as pets. The animal (or technology) is not just passively transferred into the household, with the inhabitants of the household remaining unaffected by its presence. There is a reciprocal process of co-production, meaning that when humans interact with animals or technologies they will be affected by their presence and existence, and vice versa. When new technologies are taken into use, the technology is changed and shaped by the user and the use conditions, while in turn the technologies change the conditions for the users (Skjølsvold, 2015).

In early domestication studies, domestication has been described as a process of four phases (Haddon, 2016a; Silverstone et al., 1992). The first phase, 'appropriation' refers to the early encounter between the technology and a household or individual. The second phase, 'objectification', points to the spatial integration of technology in daily life, namely where the technology is placed or stored in the household. The third phase, 'incorporation', points to the temporality, addressing when the technology is used, by whom, and for what purpose, while the fourth and final phase, 'conversion', deals with when the technology is mobilized as part of the user's identity and how people use the technology to present themselves to others (Haddon, 2016b). Through the four phases, the users' view of the technology changes from considering it new and exciting to a taken-for-granted object that is incorporated into their daily routines and practices (Skjølsvold, 2015). The notion of domestication has been particularly used to study various media technologies (e.g. Berker et al., 2005) and the introduction of ICT products (e.g. Lie & Sørensen, 1996), but can be applied to all kinds of technologies or concepts, such as the domestication of gender balance politics in academia (Lagesen, 2021) or climate change and policy (Ryghaug & Næss, 2012).

Another strand of domestication has been developed by scholars in Trondheim, Norway, and is therefore sometimes referred to as the 'Trondheim model' of domestication (Ask, 2011; Skjølsvold, 2015). It is based on the works of Sørensen and colleagues (Lie & Sørensen, 1996, 2005; Sørensen et al., 2000), who suggest that domestication can be studied through three dimensions – practical, symbolic, and cognitive – rather than through phases, as suggested by Silverstone. The practical dimension refers to the development of routines and patterns of use when a technology is made part of daily life, whereas the symbolic dimension is about the meaning making, identity, and self-representation related to the technology. The cognitive dimension is related to learning processes and knowledge, in terms of learning how to use a technology, and how users learn from each other (Sørensen, 2005).

Domestication is an ongoing process, not something that happens just once or in a harmonious linear process. Thus, artefacts can be 're-domesticated' if the circumstances change and the artefact either takes on a new role or is 'dis-domesticated,' if it is discarded (Sørensen, 1994), such as when a phone is used by a different family member to fulfil a different purpose than previously, and then discarded because it is outdated or broken. Independent of the models, domestication perspectives point to users of technologies not as submissive and passive recipients of technology, but as active actors who are taking part in shaping the role of technologies and their influence (Skjølsvold, 2015), which is in line with most co-productionist and constructivist accounts of user-technology relations within STS (e.g. Jasanoff, 2004; Pinch & Bijker, 1984).

In my case, it has not been possible to study the domestication phases of appropriation, objectification, incorporation, and conversion, as initially suggested by Silverstone, since end-user flexibility technologies and incentives have not yet been implemented in the Norwegian mass market. However, in the cross-cutting analysis (Chapter 9), I draw on the findings from the four research papers (Papers 1–4) and discuss expectations regarding the domestication of end-user flexibility mechanisms and incentives in terms of symbolic, practical, and cognitive dimensions. In this way, I aim to tease out what electricity consumption means in daily life for users and what changes in consumption might entail across the practical, cognitive, and symbolic dimensions. I argue that introduction of end-user flexibility technologies or incentives in many cases would be a redomestication of existing technologies and activities in households, and that artefacts may be given new meaning and new roles as flexible resources in the home.

3.2.2 Previous studies of domestication of smart systems and technologies

Scholars have previously studied the domestication of smart grid technologies and systems by analysing what happens when technologies are tested in real-life situations. There have been studies of feedback monitors (e.g. Hargreaves et al., 2010, 2013; Skjølsvold et al., 2017; Wallenborn et al., 2011), automated energy management systems (e.g. Nyborg & Røpke, 2013), living lab projects (e.g. Hansen & Hauge, 2017; Korsnes et al., 2018), and smart home technologies (e.g. Hargreaves & Wilson, 2017).

When conducting one of the first qualitative field studies of real-time energy monitors in households, Hargreaves et al. (2010) focused on British householders' motivations for acquiring real-time monitors, how they had been used, how feedback had changed consumption, and the monitors' limitations. It was found that in some cases the monitors led to feelings of empowerment among householders, as the users felt an increased sense of control and took stronger actions to reduce their energy consumption, in addition to seeking further information, assistance, and advice to reduce energy consumption. In other cases, the users felt disempowered, as the information they received created feelings of inadequacy, discouragement, and guilt because their contributions were perceived as futile in the face of large political, social, and environmental problems. Hargreaves et al. conclude that if smart energy monitors are to realize their potential, the contexts must be supportive of changes in energy consumption patterns: 'Smart energy monitors, it would appear, are only as good as the household, social and political contexts in which they are used' (Hargreaves et al., 2010, p. 6119).

Furthermore, Hargreaves et al. (2013) report the long-term effects of the smart energy monitors. Over time the monitors became backgrounded within daily household routines and practices, and the monitors increased the users' knowledge and confidence in terms of the amount of electricity used. However, at a certain point, the monitors did not necessarily motivate or encourage a reduction in electricity consumption. Hargreaves et al. (2013) claim that the knowledge gained by the householders could have made it harder for users to change their practices, as they had realized the limits to their potential for saving energy, and that in turn could have 'hardened' their energy use patterns and led to feelings of frustration due to the lack of wider policy and marked support. They conclude that it is not sufficient to make energy visible through smart energy monitors in order to reduce domestic energy demand. Also, energy policy measures are necessary to establish transition pathways to sustainable and low-carbon energy economies (Hargreaves et al., 2013). Other scholars, such as Wallenborn et al. (2011), and Skjølsvold et al. (2017), have drawn similar conclusions. For example, Wallenborn et al. (2011) argue that smart monitors should be accompanied by deeper transformations of cultures related to energy consumption, and that devices must become much ‘smarter’ in order to support sustainable energy consumption patterns.

Moreover, a study of Norwegian and UK households’ domestication process of in-home electricity display monitors suggest that the displays trigger new practices for monitoring electricity consumption (Winther & Bell, 2018). The display monitors were checked regularly by the householders and became a topic of conversation internally, both during and in months after installation. Winther & Bell (2018) also suggest that the presence of the display influenced the users’ electricity consumption, in addition to affecting social dynamics and potentially leading to conflicts in the households. For example, in some cases the displayed information about consumption justified nagging, but in other cases it served to correct incorrect assumptions and thus smoothed friction between household members.

The abovementioned studies of energy feedback monitors have illustrated the domestication process of visual energy information technologies and how consumption may be changed when there is easily accessible information available in visual form (e.g. Hargreaves et al., 2010, 2013). They have also shown how the presence of such information has the agency to influence norms and practices in households, far beyond aspects related directly to electricity consumption and monitoring (e.g. Winther & Bell, 2018). The findings suggest that we should be aware about framing technologies, such as energy feedback technologies, as neutral in the sense that that they provide objective information about energy consumption, when their presence may influence, for example, the social dynamics in households.

When it comes to motivations for engaging with smart energy systems for a more flexible consumption, studies have shown that users’ engagement are triggered by factors beyond economic rationality. For example, when studying pilot users of home automation energy management systems, Nyborg and Røpke (2013) found that the flexibility potential was influenced by the users’ willingness, family composition, life situation, and household infrastructure. They identified five user profiles: the technical, the economical, the curious, the participating, and the comfortable. Users’ motivations for being flexible in their electricity consumption varied from ‘contributing to technological and societal development' and 'learning something new about energy and electricity,' to being flexible 'for the sake of the environment', and to save' money and do a good deed' (Nyborg & Røpke, 2013, p. 665). Similar findings were made by Henriksen et al. (2021) when they analysed domestication processes of smart charging in a pilot project in Norway. They found that electric vehicle (EV) owners' motivations went beyond economic rationalizations for participating in the smart charging pilot project and engaging in further use of smart charging; their motivations included fire safety aspects and speed of charging, interest in and more joy from using smart home technology, practical and economic benefits, and improved physical comfort. Henriksen et al. (2021) argue that the way motivations for using smart home technologies are articulated impacts the users' potential for future flexibility and for optimalization of the electricity grid. The above-discussed studies show the importance of broadly examining flexibility potential and motivations, as these may vary between users, and give insights into reasons why people may want to engage in flexibility practices.

With regard to negotiations between developers and users, Hansen and Hauge (2017) studied what happened when project developers and participants in a living lab project discussed and negotiated smart grid technologies that were installed in the participants' homes. The study addressed how the inscription process of control was dynamic and included negotiations among the study participants and the lab owners, as the participants had suggestions and demands that had to be negotiated by the partners. Project developers anticipated that the users would adopt more passive roles than they did, and thus the inscribed moral of passivity in the scripts clashed with the users' desire for control over certain technologies. Hansen and Hauge (2017, p. 122) claim that the de-scripting from the users 'exhibited signs of energy citizenship, in which they engaged with energy as a meaningful part of their practices'. They (the authors) emphasize that control in smart grids may lead to undesired types of control over users, thus reflecting previous research findings (e.g. Davidoff et al., 2006; Hargreaves et al., 2015).

Altogether, the studies referred to thus far in this subchapter reveal how technologies or systems may become part of daily life routines and used in unintended ways, beyond their primary purpose. In some cases, the initial scripts needed to be negotiated and adapted by developers for them to be accepted by the users. The studies also demonstrates how, in some cases, domestication of certain technologies or systems spurred engagement and interest among users, and revealed interest and motivations beyond economic rationality, such as environmental considerations and serving the common good. In other cases, the domestication of new technologies or systems that were intended to change energy consumption was restrained by, for instance, family composition and life situation. Smart energy technologies could even foster feelings of inadequacy, disempowerment, and frustration in the absence of political initiative and support. Jointly, the studies point to the complexity of energy demand and consumption in households, and how this is intertwined with a bundle of daily activities and routines, in addition to culture, values, and norms, which is one of the topics addressed in this thesis.

Hargreaves and Wilson (2017) argue that smart home technologies are technically and socially disruptive, and that users need to adopt a range of strategies to cope with these disruptions, which requires effort and work on the part of the householders. In this thesis I am interested in the disruptiveness of smart technologies and flexibility incentives, and I examine the potential addition to household labour related to flexible electricity consumption. Additionally, scholars have noted that much of the energy research from social sciences and humanities focuses on new technologies, such as smart meters and feedback technologies, instead of household technologies used in domestic daily life (Mourik et al., 2017). This tendency is echoed in the literature summarized above in this subchapter. Hence, scholars have advocated a broader understanding of what the home is and what it reflects in studies of smart home technologies (Gram-Hansen & Darby, 2018), and an increased focus on material objects in daily life and cultures that shape the way users engage in energy efficiency and reducing in their energy demand (Ingeborgrud et al., 2020).

This thesis studies the dynamics of daily life and energy consumption with regard to householders' abilities and willingness to engage in end-user flexibly practices in a domestic context. It also discusses the cultural and societal context in which electricity is consumed, and the energy justice implications of increased flexibility.

3.3 Energy justice

Low-carbon transitions are often viewed as positive, as it is supposed that they reduce carbon emissions. However, they can also fail to address existing injustices and create new injustices and vulnerabilities, such as exclusion and inequality (Sovacool et al., 2019a). Injustices associated with low-carbon transitions have gained increased attention among energy scholars in recent years, which has given rise to the concept of 'energy justice'. Energy justice is connected to and builds on traditions of environmental justice and climate justice (Baker, 2016), and the notion of 'just transitions' (Heffron, 2021).

In North America, in the 1970s, the environmental justice movement emerged as a response to the disproportionate distribution of environmental burdens and associated risks, often borne by minority and low-income groups (Bass, 1998; Jenkins, 2018). According to Bass, environmental justice meant 'the fair treatment and meaningful involvement of all people regardless of race, colour, national origin, or income with respect to the development, implementation, and enforcement of environmental laws' (Bass, 1998, p. 83). Even though there has been extensive uptake of environmental justice perspectives by scholars, the environmental justice agenda has been critiqued for having little impact beyond the grassroots' level and local concerns in the United States (Jenkins, 2018).

Spawning from environmental justice, the climate justice movement emerged in the 1990s due to concerns about global climate change. The focus of climate justice has been 'effective global justice transitions that can deal with the implications of the inevitable consequences of rapid climate change for vulnerable groups in the (not exclusively) Global South' (McCauley & Heffron, 2018, p. 1). The notion of justice is both analytically and normative in terms of addressing, understanding, and intervening with injustices. According to Heffron et al. (2015), both climate and environmental justice have had limited success due to definitions and scopes being too broad, which in turn has made it difficult to use them as concepts in economics and policy. However, it has been suggested that energy justice has the possibility to avoid the challenges of climate and environmental justice scholarship by building a stronger foundation for its core meaning and value, which can make energy justice concepts transferable from education to practice (Heffron & McCauley, 2017).

The notion of energy justice, which gained ground around 2013 (Heffron, 2021), is that all individuals should have access to safe, affordable, sustainable energy, and be able to have a decent lifestyle, in addition to the opportunity to take part in energy-related decision-making processes (Bazilan et al., 2014; Carley & Konisky, 2020; Middlemiss & Gillard, 2015; Sovacool & Dworkin, 2015). Sovacool states that energy justice 'recognizes that energy needs to be included within the list of things we prize; how we distribute the benefits and burdens of energy systems is pre-eminently a concern for any society that aspires to be fair' (Sovacool, 2014, p. 15).

Energy justice frameworks have mainly conceptualized social equity in energy in relation to three core tenets of justice: distributional justice, recognition justice, and procedural justice (Jenkins et al., 2016; McCauley et al., 2013). According to Jenkins et al. (2016), distributional justice concerns the distribution of burdens and benefits, and when energy injustices emerge, such as due to the siting of energy infrastructure and access to energy services. Recognition-based injustices concern who is affected, by addressing which sections of society are misrepresented or ignored, by for example recognizing various perspectives rooted in social, ethnic, cultural, gendered, and racial differences. Procedural justice focuses on fairness in the process, such as decision-makers' engagements with affected communities.

Recently, emerging themes such as epistemic justice (Kidd et al., 2017; Valkenburg et al., 2020), cosmopolitan justice (Moellendorf, 2002) and restorative justice have gained importance (Hoffman et al., 2021; McCauley et al., 2019). Cosmopolitan justice emphasizes that all humans worldwide have equal worth (McCauley et al., 2019), while restorative justice is concerned with repairing harm and preventing damage from occurring, such as identifying who are at risk of becoming 'energy victims' or being 'energy-poor' (Hazrati & Heffron, 2021). Epistemic justice refers to unfair treatment with regard to issues of understanding, knowledge, and participation in communicative practices (Kidd et al. 2017). Sovacool et al. (2017b) have introduced an alternative approach to energy justice, through a ten-principal decision-making framework, centred on the following principles: availability, affordability, due process, transparency and accountability, sustainability, intragenerational equity, intergenerational equity, responsibility, resistance, and intersectionality.

From the growing body of energy justice literature, other related justice concepts have emerged in recent years to address energy-related injustices for people, such as fuel and energy poverty, energy burden, energy vulnerability, energy insecurity, and energy inefficiency (Jessel et al., 2019). Conceptualizations of 'flexibility justice' and 'flexibility capital' (Powells & Fell, 2019) have been developed, particularly with regard to end-user flexibility. Despite the growing body of literature, it has been noted by some scholars (e.g. Heffron & McCauley, 2017; Ingeborgrud et al., 2020) that little research has been done on the use of energy justice in practice. In the next section, I draw attention to some scholars who have deployed energy justice frameworks in studies of flexibility and energy consumption.

3.3.1 Previous studies of energy justice and user flexibility

In drawing on energy justice and social practices theory to study energy consumption and energy efficiency in low-income households in the US, Xu and Chen (2019) found that low-income households had fewer energy-efficient appliances and insufficient access to smart grid technologies. Furthermore, low-income householders engaged more often in energy practices throughout the day than other householders, and thus showed the least pronounced morning and evening peaks in consumption. Xu and Chen (2019) suggest that low-income households had relatively inflexible schedules compared with other income groups, and higher barriers that prevented them from accepting demand response programmes. Moreover, the authors argue that an essential step toward energy justice is to help low-income householders to be relieved of their energy burdens, improve their energy efficiency, and engage in further demand response programmes.

Thomas et al. (2020) applied energy justice (distributive, procedural and recognition) as an analytical lens through which to explore the social acceptability of energy systems flexibility and governance in the UK. They argue that 'Energy justice matters for system flexibility because to a large extent, the success or failure of various strategies for providing it will be contingent upon the active involvement or passive toleration of lay citizens' (Thomas et al., 2020, p. 2). By identifying energy justice discourses related to energy systems flexibility, the keys to social acceptance were identified as concern for vulnerable groups, dissatisfaction with centralized energy providers, and desire for household and community participation. Thomas et al. (2020) also found that concern for vulnerable groups and recognition of their needs constituted the most salient discourse within and across members of the public in England, Scotland, and Wales.

Milchram et al. (2020) stress the moral implications embedded in the design and implementation of smart grid systems. They claim that energy justice is one of the most comprehensive frameworks with which to address moral implications, such as data privacy, user responsibility, and distribution of responsibility. However, it is limited with regard to smart grids and in terms of concrete guidelines for designers and policymakers. In seeking to fill this gap, Milchram et al. (2020) draw on four Dutch smart grid pilot projects, to study how design choices in smart grid projects impact energy justice. Their findings suggested that the development and design of smart grid systems impact distributive justice, recognition justice, and procedural justice, thus stressing the importance of 'fairness in data governance, participatory design, user control and autonomy, technology inclusiveness, and the design for expansion and replication' (Milchram et al., 2020, p.1). The authors provide a set of concrete recommendations for technology developers and policymakers, not only for smart designs but also for equitable and inclusive designs for smart grid systems, and they encourage further exploration of the feasibility of governing smart grids as commons, and of the relationship between trust and perceptions of justice.

Powells and Fell (2019), who have conceptualized the terms 'flexibility justice' and 'flexibility capital', suggest that the ability to be flexible is affected by a wide variety of sociotechnical factors and is determined by what they call 'flexibility capital'. Drawing on the sociological understanding of capital, with reference to Bourdieu (1986), they suggest that the notion of being flexible extends financial resources and defines it as 'the capacity to responsively change patterns of interaction with a system to support the operation of that system' (Powells & Fell, 2019, p. 57). Furthermore, Powells and Fell argue that levels of flexibility capital vary in populations and this has implications for (dis)comfort and (in)convenience involved in economizing flexibility capital and may affect the availability of services and hence freedom of choice among less affluent users. They claim that there is a risk of locking flexibility-related injustices into energy infrastructures, market design, and governance, as seen in labour markets. Powells and Fell (2019) introduced the concept of 'flexibility justice' as a frame for such issues of fairness. The concepts were not tested empirically by the authors, but they do provide a useful lens through which to explore and operationalize the capacities of users to become more flexible and how those capacities are framed.

Scholars have encouraged increased attention towards energy justice in research and policy (e.g. Heffron & McCauley, 2017; Ingeborgrud et al., 2020). In this thesis, I aim to respond to this call by addressing the potential justice implications associated with end-user flexibility in a Norwegian context. By using energy justice perspectives in research on electricity consumption and flexibility, I open up for discussions about fairness and justice, such as inclusion and exclusion in design and decision-making processes, distributions of burdens and benefits, and which users are affected and in what way. Throughout this thesis, energy justice perspectives are operationalized in different ways. Paper 2 draws on the energy justice literature to discuss the various alternatives that end users have for consuming electricity flexibly, considering flexibility capital and how this poses challenges at various levels of society. Paper 3 build on Paper 2 and discusses whether some end users are more prone to being in a situation of flexibility poverty, where electricity consumption is locked into certain patterns due to the organization of society. The cross-cutting discussion (in Chapter 9) questions framings and solutions that are envisioned to encourage flexible domestic electricity consumption, and what flexibility really is and for whom.

How the different parts of the thesis address end-user flexibility by using various theoretical resources and concepts is summarized in Table 2.

Table 2: Overview of research questions addressed in the research papers (Papers 1–4) and in the thesis as a whole, and key concepts

Title	Research questions	Key concepts
'Det fleksible mennesket 2.0: Om sosiale relasjoner i fremtidens digitale elektrisitetssystem'	• How are problems with the current electricity distribution grid presented, and what is the envisioned contribution of digitalization of the grid? • How are consumers imagined in the production of end-user flexibility? • What kind of technologies, forms of organization, and price mechanisms are envisioned, and how are they expected to work?	Sociology of expectations Imagined publics, Knowledge deficits
'Justice aspects of flexible household electricity consumption in future smart energy system'	• 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 does the difference between their framings have for sustainable energy transitions?	Energy justice Energy transitions Flexibility capital Framings Resource man Flexibility woman Flexibility work
'Flexibility poverty: "Locked-in" flexibility practices and electricity use among students'	• How do students' living conditions, daily life practices, and social norms affect their perceptions and abilities with regard to flexible energy consumption, both individually and collectively? • How do students' ability or inability to practice flexibility relate to broader issues of energy justice, such as vulnerability to flexibility poverty?	Lock-ins Path dependency Energy policy Energy justice Just transition Flexibility poverty
'Flexible energy cultures? How accelerated energy transitions and flexibility needs affect the understanding of energy consumption amongst Norwegian households'	• How is energy consumption currently understood by electricity end users in Norway against the backdrop of the new context of an accelerated energy transition? • Has the increased scholarly and policy focus on flexible consumption changed the way Norwegians make sense of and evaluate their own energy consumption?	Energy culture Accelerated energy transitions Everyday practices Conscientious consumption
Just Flexibility? The Envisioned Role of End Users in Future Energy Systems	Overall research questions: • How is flexible electricity consumption shaped by expectations, energy culture, and everyday practices? • What are the energy justice implications of end-user flexibility?	Expectations User configurations Scripts Domestication Labour Energy cultures Energy justice

4. Methods

Scholars have urged for more methodological openness in the sense that choices of methods must reflect what researchers seek to study (e.g. Sovacool et al., 2018; Tjora, 2021). In this chapter, I reflect openly on the methods I have used and my methodological choices.

The thesis is situated within a constructivist research tradition, meaning that the research findings in this thesis do not uncover what are often considered new truths or facts. According to Law (2004, p. 143), methods are not, and never can be innocent or purely technical because they do not 'report' on something that is already there. Rather, methods are performative in the sense that they help to produce realities (Law, 2004). I view my research and findings as co-constructions that have emerged from interactions with the research field, study participants, the data, interpretations, discussions, and collaboration with others. I have chosen to focus on some aspects and stories about end-user flexibility, and therefore other stories have been left untold.

My position as a PhD candidate and my work undertaken for this thesis are affiliated with the research centre CINELDI' (Centre for Intelligent Electricity Distribution). This is one of the Centres for Environment-friendly Energy Research (FMEs) in Norway. FMEs are long-term (five to eight years) national centres that are intended to integrate academics into industries, research institutes, private companies, governmental industries, and regulating bodies, in order to promote environmental innovations and clean energy transitions (Silvast & Foulds, 2022). FME CINELDI aims to develop the electricity grid of the future and is working toward digitalizing and modernizing the electricity distribution grid for higher efficiency, flexibility, and resilience, in addition to enabling a cost-efficient realization of the future flexible and robust electricity distribution grid (Kjølle, 2021). I am involved in the work package concerned with 'flexible resources in the power system' (WP5), and the initial objective of my PhD project was to 'understand mechanisms and incentives for motivating user flexibility'.

Research partners, power grid companies, system operators, power market operators, technology providers, member organizations, and public authorities are all involved in the research centre. Such actors can be regarded as participants in 'techno-epistemic networks' (Ballo, 2015; Rommetveit et al., 2020), as they are part of groups producing knowledge for the development of policy and innovation, due to their competence and expertise within the field. Technology developers' expectations relating to the future tend to influence technology development processes (Skjølsvold & Lindkvist, 2015). Thus, to gain insights into relevant stakeholders' expectations about 'smart grid' developments and the role of users, I considered it important to talk to actors who were directly involved in development and research from a 'grid' perspective.

4.1 Participants

For this thesis, empirical data were collected from experts, traditional householders, and students, and comprised semi-structured interviews, illustrations, and written narratives, as shown in Table 3.

Table 3: Overview of the study participants and data collection methods

Participants	Year	Interviewees	Illustrations	Narratives	Paper
Experts	2017–2018	11*			1 & 2
Traditional householders	2017–2018	26	14**		2 & 4
Students	2018		75	17***	3
Total		37	89	17	

*Paper 1 draws on nine expert interviews, and Paper 2 draws on two additional interviews.
**14 of the 26 interviewees provided illustrations.
*** 17 of the 75 student participants provided written narratives.

I started the collection of empirical material for my PhD project by interviewing actors in research and industry who worked within smart energy development, in order to understand their views on users' electricity consumption and motivation for flexibility. In addition to interviewing some of those actors, I also took part in CINELDI seminars and conferences. My presence during those encounters, as a social scientist, might have affected some of the discussions to the extent that they included more elements of everyday life and the social aspects of electricity consumption and flexibility. However, being present allowed me to observe and participate in discussions, and thus deepen my understanding of the challenges in the energy system and expectations regarding users. Probing the experts about their understandings and expectations about end-user flexibility was relevant too, as they were in positions to influence societal and technological developments and policies that will eventually affect end users.

To understand users' electricity consumption and motivations for flexible consumption, it was important to study them (i.e. the consumers). Therefore, I collected empirical material from 'traditional' householders and students. By 'traditional', I mean a household consisting of one person, couples, or families. When referring to the students, I sometimes describe them as 'untraditional' householders to emphasize that they often live together with other adults, to whom they are not related. In the general population in Norway, this is less common than living with the family, a partner, or alone.

Scholars have addressed the lack of participation from end users in energy studies, critiquing the use of, for example, 'imagined consumers' and basing expectations about consumers on assumptions that are poorly anchored in empirical data, as opposed to the use of actual consumers (Bergman et al., 2017; Walker et al., 2010), or the use of people that are highly interested in technology and are highly competent, and also known as 'resource men' (Strengers, 2014). The use of resource men or imagined consumers with reference to development and deployment of technologies has been criticized because the technologies work well for a restricted number of people, while those in other social groups are overlooked (Skjølsvold and Lindkvist 2015; Strengers, 2014). Thus, my decision to include narratives from the wider population rather than pilot users or early adopters in order to study the users' experiences, expectations, norms, and potential challenges regarding end-users' flexibility was crucial as a way to avoid the above-mentioned pitfalls. A further consideration was that the approach has been encouraged by scholars in the energy field in the social sciences and humanities (e.g. Sovacool et al., 2019b).

For the first group of users, I made a strategic selection of study participants among traditional householders, striving for heterogenicity to include narratives from various social groups in the population. The selection of participants resulted in 26 householders (17 households) that varied in their socio-economic, geographical, and demographic characteristics. The interviews were held in the householders' place of residence, with either one or two of the householders participating in each interview. The collection of data from the traditional householders was relevant in order to gain insights from users in the wider population, as well as insights into their experiences of, and reflections on end-user flexibility, as it is envisioned by policymakers and industry actors that users will engage more with the energy system in the future (e.g. Olkkonen et al., 2017; Parag & Sovacool, 2016; Ryghaug et al. 2018; Wesche & Dütschke, 2021).

Furthermore, scholars have called for research addressing how specific groups, such as youths, are affected by efforts to make energy consumption 'smarter' (Robison et al., 2020). To address such concerns, some scholars have studied particular social groups, such as vulnerable consumers (Shirani et al., 2020) and elderly consumers (Barnicoat & Danson, 2015; C. J. Brown & Markusson, 2019). Even though it has been common in other disciplines to use students as proxies, for instance in psychology (Hanel & Vione, 2016), students have rarely been studied as a distinct social group of electricity consumers, particularly in studies of end-user flexibility. Some exceptions are studies of how residents, including students, have engaged with smart home technologies (e.g. Larsen & Johra, 2019), and studies aimed at understanding the concept of demand side response and flexible practices in shared spaces (e.g. Higginson, 2014). There have also been studies of ventilations systems (Rotger-Griful et al., 2016) and elevators in student dormitories (Rotger-Griful et al., 2017). Accounts from students can be useful to produce knowledge about potential future electricity consumption patterns, as young people may adapt practices and habits that become decisive for their future consumption (Christensen & Rommes, 2019). Also, student life is typically different from other phases of life, such as childhood and adulthood, in terms of alternative and temporal living and life situations. Students typically have low incomes, they tend to live with others, are renters, are outside the nine-to-five job regime, have fewer family responsibilities, and are novices in adult life. Therefore, studying students as a social group is an interesting way to gain knowledge about electricity consumption by young adult users in 'untraditional' households.

4.2 Generation of empirical data

When choosing an approach to gathering data about electricity consumption and flexibility, I was faced with several choices that would be applicable and that had different strengths and weaknesses. The advantage of holding interviews is the possibility to 'dig deep' and to access people's experiences and opinions about a specific theme (Turner, 2010). When doing social science research, there is often an expectation that qualitative data collection means holding interviews (Tjora 2021; Widerberg, 2001). Tjora (2021, p.18) claims that this is unfortunate, as the boundaries for what interview data can reveal (or the interview data's ontological status) can be stretched.

My choice to conduct interviews seemed obvious when I planned my project, given the above-mentioned expectations. As an alternative to one-on-one interviews, organizing group interviews could have produced a different set of knowledge, as group members can provide prompts to talk, and they can correct or respond to one another (Macnaghten & Myers, 2004, p. 65). Alternatively, shorter, 'focused interviews' (Tjora 2021, p. 140) could have meant that I could have increased the number of study participants and reduced the time spent on each interview, which in turn could have given me additional perspectives from the group of experts. However, one-to-one interviews gave me the opportunity to follow up questions and have the experts clarify their answers if there were elements I did not fully grasp. If the expert interviews had been held at a later stage in my project, when I had more insight into the field, either group or focused interviews could have been more appropriate.

When interviewing both experts and traditional householders, I used semi-structured interview guides to help me guide the conversations, while also having the opportunity to follow up on new topics that came up during the conversations (e.g. Widerberg, 2001). The questions for the experts were mainly about future challenges in the electricity system, expectations regarding end users, and possible flexibility techniques. The questions for the householders were mainly about daily life in the household, norms and practices in electricity consumption, and flexibility. In some parts of the interviews, I drew on the expert interviews in the conversations with the householders, to obtain the householders' perspectives on the solutions that the experts envisioned would be most successful to promote flexibility among end users.

When collecting data among the householders, the inclusion of more observations could have provided more knowledge about the householders' practices, particularly as I held the interviews in the householders' homes. In some cases, I was given a tour of the household, or shown specific areas or technologies in the homes, such as a newly installed smart meter or an advanced electric water heater. During the interviews I drew on my observations in the conversation, such as by asking about indoor temperature or the use of slippers. Additional strategic observations during each interview could have provided knowledge about what the householders did in practice, in addition to what they said they did during the interviews (Tjora, 2021, p. 62).

Nine of the interviews were done with two adult householders present (couples). On the one hand, interviewing couples or multiple householders, is a strength in that it can 'encourage spontaneous further discussion, providing richer, more detailed and validated accounts than those generated by interviews with individuals' (Valentine, 1999, p. 68). On the other hand, interviewing one person in a household may give the interviewee more freedom to express their individual views (LaRossa et al., 1981). The dynamic of the interaction between the couples in the interviews generated knowledge about their daily practices, similar to dynamics that can be found in group interviews (Macnaghten & Myers, 2004). Some of the one-to-one interviews were done with householders living alone and therefore their individual views represented their households alone. The interviews with couples resulted in more detailed descriptions and in-depth reflections compared with the one-to-one interviews, as they discussed, corrected, and responded to their partner's statements. They also provided some insights into the division of domestic labour within the household, thus highlighting issues related to gendered dynamics, which was interesting considering the potentially added workload for households related to changes in electricity consumption.

4.2.1 Illustrations as part of interviews

> Focusing on the visual level allows people to go beyond a verbal mode of thinking, and this may help include wider dimensions of experience, which one would perhaps neglect otherwise. (Bagnoli, 2009, p. 565)

As it was important for my research to understand the householders' daily activities, electricity consumption, and flexibility potential, I asked the interviewees during the interviews to illustrate an ordinary day in their household. I found this method useful in the interview setting, as I was able to use the illustrations to follow up with questions about the householders' daily life, routines, and flexibility, while also having the illustrations as a visual account of a full day. In some cases, I was given a simple timeline, as shown in Figure 1.

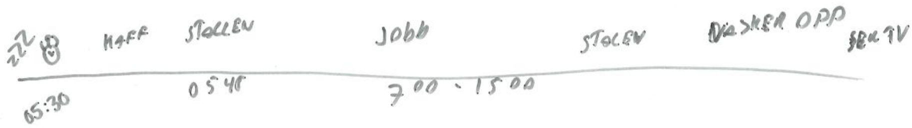

Figure 1: Example of a simple timeline: coffee, stable, work, stable, do dishes, watch tv.

In other cases, I was given detailed timelines of the households' electricity activities for example, marked with variations during the week and seasons (Figure 2).

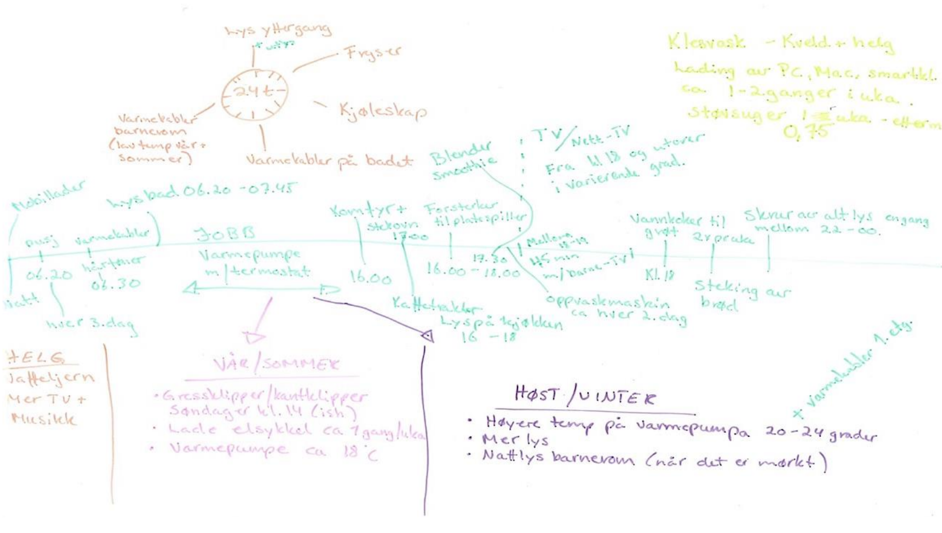

Figure 2: Example of a detailed timeline

Figure 1 is limited in the sense that there is not much additional data besides the timing of the start of the day, meals, and work hours, but it does give information about the tendencies of the daily rhythm of the interviewee. Even though some of the data made little sense on their own, I found them useful in many subsequent interviews as 'openers' or 'icebreakers' (Morrow, 1998). By contrast, the drawing shown in Figure 2 contains a lot of detail and is a source of knowledge about the household's activities during weekdays, weekends, and seasons, in addition to the technologies installed and used in their home. Some interviewees were more active and talkative than others, and this was also the case with their illustrations. Some completed the task with enthusiasm, while others were more hesitant when asked to illustrate their electricity consumption. I found that those who were interviewed in couples typically gave a more detailed account of their consumption of electricity, both verbally and in their illustrations, as they discussed their daily activities with each other and spent more time on the illustrations. In the one-to-one interviews, I was more active in the conversations while the interviewees were making their illustrations, and I was more alert to filling potentially silent moments. From that experience, I realized that time for the interviewees to reflect was important, in addition to providing a clearly stated task. This knowledge came in handy when I later collected illustration data from the students.

4.2.2 Illustrations as primary data

The collection of data from drawings provided knowledge about the participants' routines and habits related to electricity consumption. However, the method is most often used in cross-cultural research or with children, when 'there is an assumption that participants will find it difficult to express themselves verbally' (Bagnoli, 2009, p. 548). On finding the method useful in combination with interviews with householders, I wanted to use the same method when gathering data from students. Bagnoli (2009) argues that the method can be applied more widely, with people of all ages.

Two of three student groups were asked during a lecture to illustrate their electricity consumption throughout the course of a full day (24 hours), including the times of various activities, and indications of which activities or technologies were easy or difficult to cut out or change (Figure 3). Most students included some information about themselves and/or their household (e.g. household with five other students, in the age group 22–26 years). The illustrations consisted of line drawings and/or text. Most students were willing to complete the task as instructed, and some added more information, and some provided less information. No explanations or added information beyond what was put down on paper during the allocated time of 30 minutes during the lecture were available, as the illustrations were collected at the end of the lecture.

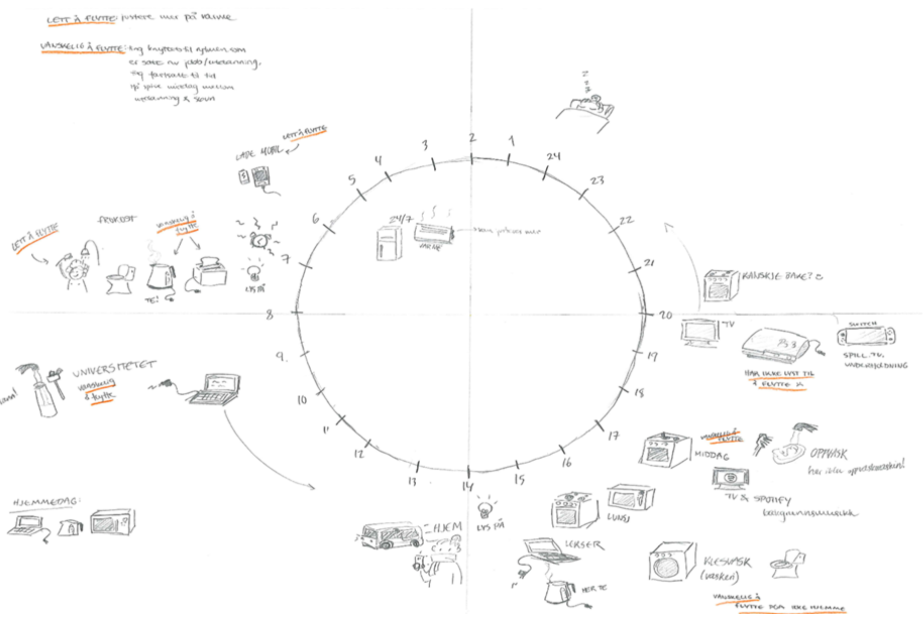

Figure 3: Example of a student's illustration of their electricity consumption in the course of a 24-hour day

The strength of using illustrative empirical data was that it afforded access to a large group of participants, and hence the collection of a large amount of data from people over a short period of time, which provided insights into their daily life, energy consumption, and flexibility in an open format. The illustrations provided detailed descriptions of the students' daily life, including their daily rhythm and activities, which household appliances and technologies they used in daily life for their studies, work, or leisure, and the use of transportation, in addition to indications of which activities they found easy and hard to change. The limitations of using the method were lack of opportunities to ask follow-up or clarifying questions, and to gain information in more depth about the potential for flexible electricity consumption.

4.2.3 Written narratives

In addition to illustrating their electricity consumption trough a day, students in one group of undergraduates were asked to write about their electricity consumption and flexibility potential, and what it would take for them to become more flexible in their electricity consumption in the future. This type of data collection method is close to what Tjora (2021, p. 207) calls ‘qualitative survey’, which he describes as a hybrid of focused interview and survey. In my case the method differed in that it had fewer, longer, and broader questions, and did not follow the proposed build-up of questions (warm up, reflection, and closure) (Tjora, 2021). However, the method was similar in that it included open-ended questions that were answered by the participants in their own words, and it did not allow for following up their answers.

I found that, compared with the illustrations alone, the combination of written narratives and illustrations resulted in more detail in the empirical material. In the illustrations, many students added some notes to explain or comment briefly on their electricity consumption, such as ‘Phone charges usually during the night. Dangerous! Bad habit.’ However, the reason why the student indicated that they charged their mobile phone during the night, even though they clearly stated it was a dangerous and bad habit, was not explained. By contrast, in the written narratives, the students discussed in depth the practices, materiality, and norms related to electricity consumption in their household.

The students’ written narratives also revealed that the students had become more aware of the consumption in their household while completing the task. For instance, one student who was living in apartment with their parents wrote:

After I had illustrated my electricity consumption, I became aware of consumption that I have never considered before. This was a single lamp that is always on in the living room. It is placed in the back of the room, on a corner shelf and therefore it is quite anonymous.

But why is it always lit? When I was young, I was told that it was lit as a precaution against burglars. If there is always some light in the home, it will look like someone is always home. A rather simple thought, but at the same time it has a lot of meaning in the household.

The written narratives nuanced the illustrations in the sense that the students elaborated on whether and why certain energy-related activities were hard or easy to cut out or move to other times, which added depth to the data. In sum, the empirical material obtained from the students were rich enough to allow for analysis, which was subsequently presented in Paper 3.

4.3 Analysis of the empirical data

The interviews were analysed using a stepwise deductive-inductive (SDI) method (Tjora 2021), which builds on the research tradition of grounded theory (GT) (Glaser & Strauss, 1967; Strauss & Corbin, 1990). The SDI method entails working in steps from the empirical material to theories or concepts (inductive), continuously checking the links back to the empirical material (deductive). The purpose of the method is to create 'conceptual generalizations', meaning concepts, models, or theory that are relevant beyond the specific case of study and supported by previous findings and theories (Tjora, 2021, p. 271). The SDI method is similar to GT in principle, but involves a simpler and more concrete approach (Henriksen, 2018). For instance, when coding the empirical material in line with GT, various rounds of coding are applied, including open, focused, and theoretical coding, whereas the SDI method has only one round of coding (open coding). Also, the SDI method has been developed with an aim of grasping the potential of collected empirical data (Tjora, 2021, p. 23), in contrast to the application of GT, for which it is often necessary to return to the field to collect more data (Glaser & Strauss 1967, pp. 45–78).

Following the SDI method, the first steps include generating empirical data, processing the material (e.g. transcribing interviews), followed by coding. The generated codes are closely linked to the empirical material, rather than predefined codes or rooted in theories. The material is then sorted into codes inductively in larger thematic groups. The larger ‘code groups’ forms the main topics of the analysis, which are linked to existing literature and theories. Main topics or code groups, and relevant theory are then used in the development of concepts, models, or theories, which are finally tested on the empirical material (for a detailed description, see Tjora, 2021). An example of coded empirical material from my study is given in Table 3.

Table 4: Example of coded empirical material

From interview	**Code**
Man: We have received the first bill now. Probably, in the new way, with the new meter. Interviewer: So, you have got it? Woman: We have had it installed, yes. Interviewer: And you have received an electricity bill after the installation? Male: Yes, I think so, but I haven’t been able to get a better grasp on when we use the most electricity during the day, or anything like that.	*New meter installed but do not have a better grasp of when they use the most electricity during the day.*
Interviewer: It may take some time before it … Male: Before it comes, yes, that might be [some time]. But if it does [come], if that is something we get access to, then it will be possible, if one is interested, perhaps not to run the washing machine when the electricity consumption is at its highest. Interviewer: You think that is something you would do? Are you paying attention to it? Woman: Yes, absolutely.	*Could be interested in steering consumption to when it is not at its highest.*

Following the methodological approach described by Tjora (2021), a conceptualization of ‘flexibility work’ was developed for Paper 2, to describe the practical alternatives of shifting or reducing electricity use in households, and emphasize the element of unpaid domestic labour involved in the task and different ‘flexibility capital’ (Powells & Fell 2019) in households. The conceptualization was developed within a Norwegian context, by studying householders’ end-user flexibility, but it can be applied in other cases and contexts.

My process of analysing written narratives and illustrations followed the principles of the SDI method, namely working inductively and deductively, starting with the empirical material. In the analytical process, the written narratives were treated as interview data in terms of coding and sorting of larger code groups and themes. It was not possible to use the same procedure to analyse the content of the students' illustrations. To get an overview of the students' electricity consumption and flexibility potential, parts of the illustrative material were quantified, thus treating the information in the illustrations as observations of specific electricity consumption. The quantification included written notes from the illustrations, such as 'Washing clothes (at laundry). Hard to move because outside home.' However, studying the illustrations solely as survey data was insufficient and would have meant losing valuable empirical data. Therefore, the illustrations were also studied as individual empirical accounts from the students. Hence, the analytical process involved moving back and forth between the observations (quantifications) and the illustrations.

Unlike interview data, which is influenced by 'intersubjectivity', whereby the empirical material is a result of the conversation between the researcher and study participant (Tjora, 2021), my empirical data obtained from the students built on 'informant subjectivity', whereby the interpretation of questions and the task were left to the participants alone (Tjora, 2021). The analysis of the students' illustrations and written narratives was based on the students' analysis of their electricity consumption and flexibility potential. Studying the narratives second-hand created a distance from the empirical material, compared with the interview material, for which I was present when during the collection and was able to detect non-verbal signals and moods, and thus took part in the creation of the material. This meant that the written narratives and illustrations had to be studied more closely compared with the empirical material I had collected first-hand.

4.4. Methodological reflections

Inviting householders to illustrate their daily electricity consumption during the interviews worked as sort of a 'breaching experiment' (Garfinkel, 1967) in the sense that it was sometimes awkward and unorthodox to ask the interviewees in all seriousness to draw their daily routines on paper, using bright colouring pens. Surprisingly, many of the householders were enthusiastic about the request. According to Zweifela and Van

Wezemael (2012, p. 15), the process of combining talking and drawing in qualitative interviews 'represents the chance to gather information on a situation in a more complete, often more complex way and, as such, make possibilities, thoughts, interpretations and world views of interviewees more tangible'. I would agree with this, as in most cases I obtained fuller and more complete descriptions of the householders' daily lives when the illustrations were included in the interviews. I would also support the second claim of Zweifela and Van Wezemael (2012), which is that the success of combining these methods is dependent on the person's interest in drawing. In some cases, rich material was produced that provided a lot of information about the householder's energy-related activities. In those cases, illustrations were a useful tool, which I found added depth to the empirical material, but in other cases they were an extra element in the conversation, which I believe did not add much empirical richness beyond driving a slow conversation forward.

In addition to conducting interviews, I found that collecting illustrations and written narratives was useful as the method produced a rather large body of empirical data in a short amount of time, and in many cases the data were rich in detail, and revealed information beyond the scope intended by my initial questions. I cannot be certain that this would have been the case if I had used different methods. The visual element in the task might have helped the participants to 'go beyond a verbal mode of thinking', and to include a wider dimension of their experiences, as noted by Bagnoli (2009). Quantifying the illustrative material gave me an overview that was useful to support arguments, indicating how many participants reported particular activities as flexible or inflexible. For example, in the process a difference became visible between the master's students and the undergraduates in terms of flexibility. However, I found that the illustrations in combination with the written narratives provided more in-depth details about the students' experiences and reflections concerning energy use and flexibility in their daily lives, which enabled discussions about their perceptions of and ability for flexible energy consumption.

Altogether, the combination of participants and different methods used to collect empirical material complemented each other in a way that gave me valuable insights into the field from various perspectives. The interviews with experts, which represented perspectives from ‘techno-epistemic networks’ (Ballo, 2015; Rommetveit et al., 2020), provided insight into expectations and understandings of end users. This was useful in order to gain knowledge about their visions for end-users’ abilities and willingness to become more flexible, and thus gain insights into stakeholders that most likely would influence developments, such as flexibility incentives, technologies, and policies, which eventually will affect end users.

The traditional householders offered in-depth descriptions, visually and verbally, of their daily routines, and they elaborated on their views in terms of how they most likely would respond to the suggested incentives suggested by the experts (price signals, automation, and information), bearing in mind their available means, abilities, and values. This finding was useful to add perspectives from a group of traditional householders, representing lived experiences, and thus shed light on the social implications of flexible consumption and smart grid technologies in a field traditionally dominated by technological and economic perspectives. The large group of students provided insights into untraditional householders, revealing different challenges and opportunities for flexible consumption, compared with traditional householders. This finding was fruitful to nuance the narrative of ‘ordinary’ householders, and thus include a larger variety of end users, thereby shedding light on challenges with flexible electricity consumption in alternative living situations and life stages.

5. 'Det fleksible mennesket 2.0: om sosiale relasjoner i fremtidens digitale elektrisitetssystem' [3]

Abstract

Fra 2019 vil alle norske hjem utstyres med en «smart» strømmåler. Dette er en liten, men viktig del av digitaliseringen av samfunnets kritiske infrastruktur. Denne artikkelen tar utgangspunkt i utviklingen av energisystemet, og studerer konkret hvordan teknologiutviklere og forskere forstår digitalt muliggjorte endringer av forbruks- og adferdsmønster. Vi bygger vår analyse på ni dybdeintervjuer av nøkkelaktører på feltet, og vi analyserer deres fremtidsforestillinger når det gjelder hvordan digitale redskaper vil gjennomsyre folks forhold til energi. I dette ligger forventninger knyttet til at teknologier som kvantifiserer og visualiserer energibruk, gjerne i kombinasjon med automatisering og nye prissignaler, vil påvirke når og hvordan vi bruker energi, og derfor også indirekte, hvordan vi lever vårt liv. Fra et systemperspektiv beskrives den digitalt medierte viljen til å endre og avstå fra energibruk som «sluttbrukerfleksibilitet». Innbakt i fremtidsnarrativene ligger tydelige forventninger til menneskelig rasjonalitet, fremtidig teknologi- og samfunnsutvikling samt forestillinger om fremtidig samspill mellom disse. Vi diskuterer videre de digitale energiteknologienes politikk, og hvordan de potensielt kan være med å produsere et hverdagslig tidsmarked hvor tjenesten som selges er å avstå fra å forbruke elektrisitet i gitte tidsrom. Dette vil sannsynligvis kunne forsterke eksisterende sosiale skiller. I lys av dette etterspør vi mer kritisk samfunnsforskning som motvekt til de enorme ressursene som i dag brukes på å fremme en såkalt «smart» teknologiutvikling og som gjerne betraktes som politisk og sosialt nøytral.

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Introduksjon

I løpet av 2019 må alle norske husholdninger bytte ut den analoge strømmåleren til fordel for en ny, digital strømmåler. Den umiddelbare effekten av byttet kan synes triviell: først og fremst at kommunikasjonen mellom kjøpere og selgere av elektrisitet automatiseres. Den nye måleren genererer imidlertid store mengder data om elektrisitetsbruk, noe som i mange land har resultert i debatter om dataeierskap, -sikkerhet og privatliv (Darby & McKenna, 2012). Om vi ser bort fra datasikkerhet som et problem, er den umiddelbart nye konsekvensen for en norsk strømkunde i 2019 at vedkommende ikke lenger behøver å lese av sin egen strømmåler. Likevel forventes den «smarte» strømmåleren å være første steg på veien mot en gjennomdigitalisert energiinfrastruktur (Ballo, 2015; Skjølsvold, 2014; Strengers, 2013) som vil endre relasjonene mellom aktører på energifeltet og radikalt forandre vanlige borgeres forhold til strøm. Gjennom å ta i bruk smarte strømnett, smarte hjem og smarte husholdningsapparater, ser man for seg å i stor grad kunne kvantifisere, visualisere og i prinsippet dermed også styre og forvalte strømmen på helt nye måter – også på husholdningsnivå.

I denne artikkelen studerer vi potensielle sosiale implikasjoner av denne formen for digitaliseringsprosess, og er interessert i hva slags fremtid teknologiutviklere, politikkutviklere og forskere forestiller seg at de nye digitale energiteknologiene skal være en del av. Et sentralt element er at teknologien i kombinasjon med nye prissignaler skal produsere en ny form for strømforbruker. Denne forbrukeren forestilles ikke kun som forbruker av strøm, men også som en tilbyder av det som ofte kalles «sluttbrukerfleksibilitet». Sluttbrukerfleksibilitet er noe som i praksis betyr at det å *ikke* bruke strøm i periodene med størst press på strømnettet, blir en tjeneste som kan selges til nettselskapet. Mens tidligere studier av visjoner for den digitale energifremtiden har fokusert på forestillinger om energisystemet (Ballo, 2015; Engels & Münch, 2015; Skjølsvold, 2014), velger vi her altså å fokusere spesifikt på ideen om fleksibilitet og hvordan fremtidens elektriske hverdagsliv tenkes å se ut.

I analysen drar vi veksler på innsikt fra teknologi- og vitenskapsstudier (STS), særlig forventningssosiologien (Borup, Brown, Konrad & Van Lente, 2006; Van Lente, 2012) samt litteratur om forestilte offentligheter (Maranta et al., 2003; Walker, Cass, Burningham & Barnett, 2010) som i vårt tilfelle tar form av forestillinger om teknologibrukere. Denne litteraturen har vist hvordan forventninger om henholdsvis fremtiden og ulike offentligheter blir performative gjennom at handlingsstrategiene til dagens aktører formes av forventningene man har. Vi snakker da om forventninger både til teknologiutvikling, hvordan teknologier antas å virke, samt forventninger og forestillinger om hva menneskelig rasjonalitet er og hvordan denne rasjonaliteten påvirker samspillet mellom mennesker, ny teknologi og endring av hverdagspraksis. Denne diskusjonen relaterer seg også til diskusjoner i arbeidslivssosiologien om forholdet mellom tidsforvaltning, identitetsdannelse og hverdagsliv. Vår analyse peker på en forventning om at digitaliseringen vil gjøre hverdagsaktiviteter til en del av en profesjonell tidsøkonomi (f.eks. Tietze & Musson, 2002) hvor handlinger som å vaske klær, lade el-bil eller se på TV blir en del av et «tidsmarked» dominert av kraftsystemets behov.

Elektrisitet, hverdagsliv og digital transformasjon

Endringer av elektrisitetsforbruk diskuteres gjerne i sammenheng med behovet for en større energisystemomlegging (Verbong & Geels, 2007) og begrunnes ofte med hensynet til miljø, klima og å begrense infrastrukturinvesteringer. Den norske ENØK-politikken (Sørensen, 2007), liberaliseringen av kraftmarkedet (Karlstrøm, 2012) og implementeringen av avanserte måle- og styringssystemer (Ballo, 2015) er alle eksempler på at strømforbruk blir gjenstand for politisk bekymring og forsøk på styring, forankret i økonomi- og ingeniørfaglige betraktninger. De siste årene har digitale teknologier og IKT-ekspertise blitt en viktig del av det politiske arsenalet for å transformere forbruket. Før vi diskuterer noen konsekvenser av dette, vil vi kort drøfte hvordan sosiologisk orienterte analyser tidligere har forstått og studert elektrisitetsforbruk.

Frem til midt på 1980-tallet var det få samfunnsvitenskapelige studier av elektrisitetsforbruk. Den dominerende forståelsen av fenomenet var at energietterspørsel kunne predikeres av tekno-økonomiske modeller for menneskelig rasjonalitet (Aune, 2007; Lutzenhiser, 1992; Sovacool, 2014). I 1980-årene ble dette utfordret av en gruppe forskere som hevdet at sosiokulturell og psykologisk analyse pekte mot mer komplekse beslutningsmodeller som utvidet og utfordret ideen om «rasjonelle» strømkunder (se Lutzenhiser, 1992; Wilk & Wilhite, 1985). Senere har samfunnsvitenskapelige studier av energispørsmål vokst til å bli et stort internasjonalt fagfelt (se Sovacool, 2014 for en gjennomgang). Sosiologisk analyse har spilt en nøkkelrolle når det gjelder å belyse hvordan kulturelle og samfunnsmessige strømninger forklarer hvordan husholdninger bruker elektrisitet, i kontrast til individuelle forståelsesmodeller (Aune, 2007; Aune et al., 2016). Et sentralt poeng er at forbruket formes av materielle, kognitive og praktiske elementer som i sum utgjør en *energikultur* (Stephenson et al., 2010).

Med et slikt perspektiv formes strømforbruk av samfunnets temporale rytme (Walker, 2014). På aggregert nivå følger strømforbruket samfunnsrytmen gjennom døgnet, uken og over år. Det som fra et energisystemperspektiv ofte beskrives som «topplasttimer», typisk morgen- og ettermiddagstimene, kan derfor beskrives som en form for sosial last (Wilhite & Lutzenhiser, 1999) hvor elektrisitetsforbruk ikke defineres av individuelle valg, men formes av samspill mellom ulike prosesser i samfunnet.

Digitale, smarte teknologier søker å endre slike forbruksmønstre. Ved hjelp av sensorer, målere og visualiseringsteknologier kvantifiseres forbruket, med mål om å skape et mer aktivt forhold til strømforbruk. Behovet for dette begrunnes blant annet med fremveksten av nye, fornybare energikilder som gir variable produksjonskurver og økt belastning på strømnettet gjennom elektrifisering av transportsektoren, spesielt økt bruk av el-biler. Utfordringen ligger i at vind- og solenergi ikke kan programmeres til økt produksjon i perioder der energietterspørselen er størst, slik som for fossile energikilder og magasinert vannkraft. For å dekke eller «balansere» strømforbruket, er det derfor om å gjøre å spre strømforbruket jevnere utover døgnet. Norges vassdrags- og energidirektorat (NVE) skriver: «Ny teknologi og nye markedsløsninger kan gi grunnlag for en mer aktiv deltakelse og bedre innsikt i eget forbruk». Nedenfor studerer vi slike forestillinger knyttet til det som ofte kalles «fleksibilitet» eller «sluttbrukerfleksibilitet».

Hvordan forstå visjoner om fleksible sluttbrukere

I denne artikkelen studerer vi hvordan forskere og bransje i skjæringspunktet mellom IKT og energi forestiller seg «fleksibilitet» og fleksibelt forbruk som digitalt muliggjort fenomen. Vi er særlig interessert i potensielle sosiale implikasjoner av utviklingen. Vi betrakter de intervjuede aktørene som deltakere i tekno-epistemiske nettverk (Ballo, 2015; Rommetveit, van Dijk, Gunnarsdóttir & Smits, 2015) et begrep som bygger på kunnskap om epistemiske fellesskap (Knorr-Cetina & Mulkay, 1983; Haas, 1992). Med tekno-epistemiske nettverk mener vi grupper av kunnskapsprodusenter med anerkjent kompetanse og ekspertise innenfor et spesifikt felt som kan påberope seg å utvikle politikk- og innovasjonsrelevant kunnskap. Fokus på nettverk heller enn fellesskap antyder at roller og identiteter ikke er permanente og stabile, men mer flytende, hybride og porøse. Vi studerer ikke aktørenes forestillinger fordi deres tanker i seg selv er interessante, men fordi vi antar at aktørenes kollektive forestillinger og forventninger er sentrale for utformingen av teknologiske utviklingsbaner og designstrategier og at de tilbyr viktige handlingsforklaringer. Slik kan fremtidsforventninger fortolkes som kunnskapsobjekter som både kan studeres og kritiseres (Brown & Michael, 2003), samtidig som det er mulig å studere hvordan de konstrueres og former teknologi- og samfunnsutviklingen.

Vi er med andre ord interessert i en bestemt type fremtidskonstruksjon. Vi studerer spesifikke språklige representasjoner av en digitalt muliggjort teknovitenskapelig fremtid. Sally Wyatt (2004) har påpekt hvordan IKT-aktørers metaforbruk på 1990-tallet var helt avgjørende for hva slags designstrategier som ble tatt i bruk i Silicon Valley for å utvikle internett. I dag er ideen om «*the information superhighway*» en klisjé, men som bærende idé om hvordan fremtiden skulle se ut, var den i sin tid avgjørende for arbeidet med å forme teknologiene. På samme måte finnes det mange studier som diskuterer hvordan fremtidsvisjoner på felt som biomedisin er ladet med håpefulle eller fryktede metaforer og hvordan disse former aktørers handlingsstrategier (Mulkay, 1993; Nerlich & Halliday, 2007) eller hvordan forventninger og forestillinger om brukere har vært med på å forme norsk el-bilpolitikk (Ryghaug & Toftaker, 2016).

Fremtidsforventninger er ofte generelle, og de er gjerne teknologioptimistiske, med hang til metaforer som «gjennombrudd» eller «fremskritt». For mange aktører er imidlertid fremtiden et umiddelbart og konkret kunnskapsobjekt knyttet til gjennomføringen av spesifikke prosjekter. Når det gjelder overgangen fra fossile til fornybare energiteknologier, har mange studier sett på hvordan teknologiaktører forestiller seg en offentlig respons, for eksempel til en fremtidig utbygging av vindkraft, kraftlinjer eller bioenergianlegg (Barnett, Burningham, Walker & Cass, 2012; Heidenreich, 2015). Et gjennomgående funn i Norge og internasjonalt er at aktørene som søker å implementere teknologiene, ofte fortolker offentligheten via ulike underskuddsmodeller (Burningham, Barnett & Walker, 2015). Offentligheten fortolkes i retning av å mangle kunnskap eller moral, og derfor som motstandere av konkrete prosjekter (Karlstrøm & Ryghaug, 2014). Derfor utarbeides strategier for å unngå at den forstilte motstanden får gjennomslag.

Vi er interesserte i fenomenet som kalles «sluttbrukerfleksibilitet» i diskusjoner om fremtidens energisystem. Fenomenet er i dag marginalt, men i norske og europeiske politikkdokumenter og prosesser fremstår realiseringen av et teoretisk fleksibilitetspotensial som sentralt. I det følgende vil vi diskutere hvordan denne typen fleksibilitet diskuteres blant norske aktører som kan sies å være del av et fremvoksende tekno-epistemisk nettverk innenfor «smart» energi.

Metode

Vår analyse bygger på intervjuer med et strategisk utvalg av ni aktører innen forskning og bransjer som arbeider med utvikling av smarte energiløsninger. Disse ble valgt fordi de har relevante roller, kompetanse og erfaringer for å belyse vårt tema (Tjora, 2012, 145). Majoriteten av informantene har en faglig bakgrunn innen elkraftteknikk og jobber med digitalisering av strømnettet i form av forskning, arbeid i nettselskaper, i klynger eller i relevante kompetansesenter. Da dette er et fremvoksende felt i endring, er dette aktører som utfordrer nettselskaper og el-bransjens tradisjonelle arbeidsmåter til tross for at flere av informantene er ansatt i etablerte nettselskaper. Dette peker på en økende heterogenitet på dette området hvor nye former for ekspertise er i ferd med å få definisjonsmakt når det gjelder å velge hvilke teknologier og redskaper som skal tas i bruk. Derigjennom ligger det også et stort potensial for å formulere hva slags samfunnsorden disse teknologiene vil bli innbakt i. Intervjuene ble gjennomført i perioden 2017–2018. Intervjuene varte fra en halv til halvannen time, og ble utført som åpne intervjuer med bruk av intervjuguide.

Intervjuguiden inneholdt spørsmål om hva informantene anser som fremtidens utfordringer knyttet til energiforbruk, forventninger til forbrukere, og hvilke mulige løsninger de ser for seg i den digitale fremtiden. Svarene fra informantene baserer seg på deres egne refleksjoner, og gjenspeiler ikke nødvendigvis deres arbeidsgiveres visjoner. Intervjuene ble tatt opp etter muntlig samtykke, transkribert og kategorisert. Sitatene er stort sett gjengitt ordrett, men vi har også enkelte steder gjort små endringer med tanke på å fremme lesbarheten. Informantene er anonymisert. Analysen av intervjuene er gjennomført med en åpen holdning til informantenes perspektiver og erfaringer, og materialet ble kategorisert med bakgrunn i dette.

Analyse: forventninger til det digitale strømnettet

Analysen tyder på at aktørene i det tekno-epistemiske nettverket har ambivalente forventninger til hva det digitale strømnettet skal være, hvordan man skal forstå menneskelig handling, og hvilke teknologier, sosiale og økonomiske mekanismer som kan bidra til endring. Vi deler diskusjonen i tre deler hvor vi a) ser på hvordan problemene med det eksisterende strømnettet skisseres, samt hva digitaliseringen av strømnettet fortolkes som å bidra med, b) ser på forestillinger om forbrukere i produksjon av det som kalles sluttbrukerfleksibilitet, samt c) ser på hva slags teknologier, organiseringsformer og prismekanismer aktørene forestiller seg og hvordan de ser for seg at disse vil virke sammen med de involverte brukerne.

Strømnettet vårt: utfordringer og løsninger

Våre informanter bygger i stor grad sin argumentasjon og forståelse rundt *samfunnsøkonomiske modeller*. Her er kost–nytte-vurderinger sentrale. Den gjennomgående motivasjonen for å fremme «fleksibilitet» handler om å begrense omfanget av fremtidige investeringer. Som en av våre informanter sa: «Forbrukerfleksibilitet kan gjøre at du begrenser behovet for hvor mye nett som må investeres i, eller hvor mye investeringer som må gjøres i nettet» (Ekspert 1).

I dette ligger det en forventning om at de siste års økende utfordringer knyttet til effekt, altså mengden strøm som går gjennom strømnettet samtidig, vil eskalere. Effektproblematikken har oppstått på grunn av endrede vaner i hverdagslivet, knyttet til nye teknologier som el-biler og induksjonstopper. I tråd med denne forståelsen forklarte en av våre respondenter med kompetanse innenfor elkraftteknikk den potensielle nytten av fleksibelt forbruk ved å bruke motorveien som metafor:

> Hvis vi ser at makslasta øker hele tida, så er det ikke lønnsomt i lengden å alltid bygge ut nettet. Kanskje man heller kan gjøre noe med den topplasta, for den er veldig få timer i året. Kan man få den fleksibel, kutte noe forbruk akkurat da, jevne ut forbruket. For ellers så blir det kø på motorveien en time i året, og da må du ha en firefeltsvei på grunn av den timen (Ekspert 1).

En av informantene i et nettselskap pekte på at nettselskapet er nødt til å kunne regne med fleksibiliteten dersom de avventer investeringer i nettet: «For oss […] er jo vi avhengig av at den fleksibiliteten […] er der når vi trenger den […]. Så den må også være tilgjengelig på julaften og på en kald februardag» (Ekspert 9). Våre informanter er samstemte om behovet for å endre husholdningenes strømforbruk og at «fleksibilitet» blir viktig i fremtidens kraftsystem. De erkjenner imidlertid at en slik fremtid vil ha konsekvenser for hverdagslivet og at det ikke vil bli enkelt å transformere forbruket. Dette skal vi se nærmere på i neste del av artikkelen.

Forventninger til brukerne i produksjonen av fleksibilitet

Våre informanter har tydelige forestillinger om brukernes motivasjon for og evne til å endre praksiser som innebærer strømforbruk. De har også klare fortolkninger av hva slags rasjonalitet som styrer valg knyttet til elektrisitetsbruk. Ofte fortolkes forbrukeren som fattig på informasjon og forståelse for hvorfor vedkommende skal endre forbruket. Digitalisering og nye former for forbrukskvantifisering og -visualisering betraktes som redskaper for å bøte på informasjonsunderskuddet. Som en av våre informanter sa:

«[forbrukerne] må ha informasjon, og de må få opplæring og informasjon, tror jeg, før de gjør noe som helst» (Ekspert 1). Denne fortolkningen av brukerne som preget av et kunnskapsunderskudd, er også identifisert i mange tidligere studier av teknologiutvikling på dette feltet (Skjølsvold & Lindkvist, 2015; Throndsen & Ryghaug, 2015).

En annen utbredt fortolkning blant ekspertene var at forbrukerfleksibilitet handler om forhold knyttet til økonomi og komfort. En av ekspertene beskrev det slik: «… jeg tror det handler mest om kostnad og komfort, og det at folk skal være fri til å gjøre det de vil» (Ekspert 5). Forestilte ønsker om valgfrihet vektlegges altså slik at det å bli fleksibel ikke peker mot et redusert komfortnivå.

Flere av våre informanter hadde et nyansert syn på brukernes rasjonalitet og deres mulige beveggrunner til å ville bli fleksible forbrukere. Et eksempel som ble fremhevet, var teknologiinteresse. Forestillingen var at enkelte brukere ville kunne bidra til mer fleksibilitet i strømnettet på grunn av en interesse for å teste ny teknologi. Dette er et kjent fenomen fra forskning på energiinnovasjoner for hverdagslivet: mange lar seg innrullere som deltakere i pilot- og demonstrasjonsprosjekter på grunn av teknologiinteresse (Ryghaug, Skjølsvold & Heidenreich, 2018; Winther, Westskog & Sæle, 2018). Ofte er det også slike brukere teknologiutviklere forestiller seg og ønsker seg når de utvikler «smart» teknologi (Strengers, 2013). I tillegg til teknologiinteresse, fremheves miljøhensyn som en viktig motivasjon. Slike sammensatte forestillinger om brukermotivasjoner kompliserer bildet for ekspertene. Som en av ekspertene sa: «Jeg tror noen trigger på at det her har nytte for miljøet, noen trigger på at de sparer penger på det. Da er utfordringen å finne ut hvordan man skal få det til» (Ekspert 1). Det er altså en forventning om at økonomi er viktig, sammen med miljøargumenter. Likevel, det er også en uttalt skepsis til hvordan økonomi vil kunne trigge atferdsendringer. En ekspert uttrykte dette svært tydelig:

> Altså nettleien er ganske høy, men strømprisen er ganske lav, og variasjonen over døgnet i Norge merkes nesten ikke på spotprisen. Så ok, kanskje kan du kan spare 17 kroner og 50 øre i året. Du får aldri noen med på det! (Ekspert 2).

Andre pekte på en motsetning i det de opplevde som et gap mellom en befolkning som på den ene siden protesterte mot endringer i kraftsystemet, men som på den andre siden ikke ville delta i dugnaden ekspertene betraktet fleksibilitetsløsninger som. Slik ble folk flest fortolket både i retning av å mangle informasjon og forståelse, og i retning av å være grunnleggende egoistiske:

> Det er ikke så mange som liker at vi bygger linjer, vindmøller eller hva som helst. Så hvis man ikke vil at vi skal bygge masse nye linjer og betale masse for det, så må vi gjøre ett eller annet med nettet vi har. Utnytte det best mulig. Og hvis man ser den problemstillingen og har lyst til å bidra med det, så kan det også være et moment, da. Men det tror jeg ikke er så viktig for mange. Det er vel helst prisen (Ekspert 5).

Denne typen påstander om sluttbrukerne som på den ene siden forstås som egoistiske og nyttemaksimerende og på den andre siden som sløsende og kunnskapsløse, er noe vi kan kjenne igjen fra tidligere debatter rundt beveggrunnene for liberaliseringen av kraftmarkedet (se Karlstrøm, 2012). Noen er enda mer eksplisitt på at den sentrale utfordringen er en mangel på interesse og vilje blant folk flest: «Altså, om du vil ha konklusjonen rått og brutalt, så er det slik at vi tror ikke at folk bryr seg» (Ekspert 7). Vi ser med andre ord en tydelig fortolkning av forbrukerne i tråd med teser om underskudd både når det gjelder kunnskap, interesse og moral (jfr. Barnett et al., 2012).

Samtidig har enkelte aktører i vårt intervjumateriale et mer nyansert blikk, og erkjenner at også forskere og bransje har kunnskapshull når det gjelder menneskelig motivasjon for å endre adferd:

> Det er jo lite [kunnskap vi har om brukers motivasjon] ut over det økonomiske. Det er ikke samlet mye annet, ting du gjør, det er ikke det. […]. Vi sorterer jo søppel uten å få noe igjen for det, sant (Ekspert 4).

Noen av ekspertene påpeker altså at den økonomiske innrammingen av borgerne hemmer forståelsen av hvordan deres valg påvirkes, hva som motiverer dem og hva som får dem til å tenke og handle annerledes rundt strømbruk (jfr. Throndsen & Ryghaug, 2015). Denne typen erkjennelse bør vies mer oppmerksomhet, da det her potensielt ligger en kime til viktig nyskaping.

Tre typer mekanismer for endret forbruk

Fortolkningen av forbrukere som i hovedsak økonomisk motiverte, uinformerte eller uinteresserte, oversettes av aktørene i det tekno-epistemiske nettverket til et sett sosiale, økonomiske og teknologiske løsningsforslag for å transformere og aktivisere det de betrakter som passive strømforbrukere. Forståelsen av menneskelig rasjonalitet blir dermed performativ på en strukturell måte og former handlingsstrategiene til aktører i det tekno-epistemiske nettverket (Barnett et al., 2012). Tre idealtypiske virkemidler dominerer i dag. Det første er informasjonsredskaper som er ment å endre kunnskap og holdninger. Det andre er nye økonomiske virkemidler for å stimulere aktive valg. Det tredje er å fjernstyre eller automatisere energivalgene for å oppnå målene uten aktiv involvering av strømkundene.

La oss først se på forslagene knyttet til informasjon. Dagens forbrukere blir beskrevet som passive, hvilket kommer til uttrykk i utsagn som at det trengs opplæring og informasjon «før de gjør noe som helst» (Ekspert 1). Flere peker på at det å endre forbruksmønster handler om bevisstgjøring: «Det handler nok om en bevisstgjøring, altså å flytte forbruket under effekttoppene. Det handler veldig mye om en bevissthet» (Ekspert 5). Flere respondenter peker på at digitale, «smarte» strømmålere åpner for nye kommunikasjonsformer slik at kunder kan bevisstgjøres på nye måter. Én pekte for eksempel på den mulige nytten av «visuell informasjon» som kan gi signaler om at «nei, nå må du være forsiktig, i en periode hvor det er behov for at folk er forsiktig med å bruke strøm!» (Ekspert 4).

Selv om mange betoner viktigheten av visuell digital kommunikasjon, har aktørene også begrenset tro på at informasjons- og holdningsarbeid alene vil transformere forbruket. Troen på digitalt mediert informasjon følges av en frykt for det de oppfatter som et underskudd på gode holdninger og handlingsvilje i befolkningen. Som en av våre respondenter sa: «Spørs hvor lenge kunden orker eller gidder det, en sånn generell holdningsendring» (Ekspert 1). En annen informant uttaler: «Mange er opptatt av […] at kunden selv skal finne ut når han skal være fleksibel […], men å tro at en kunde kan reagere på timebasis gjennom døgnet, det har jeg ikke noen som helst tro på» (Ekspert 4).

Denne frykten for forbrukerne handler på den ene siden om fortolkninger som peker på latskap og umoral. På den andre siden tror mange at kundene mangler kompetanse og at forbrukerne ikke vil være i stand til å forstå abstrakt samfunnsnytte kommunisert via kompleks teknologi. Mange hevder altså at den jevne strømforbrukeren ikke vil være i stand til å forstå argumenter for et behov for å flate ut forbrukskurver:

> Det er nok vanskelig å forstå sammenhengen mellom at vi skal elektrifisere samfunnet og at vi da også blir nødt til å bygge ut infrastruktur som kommer til å koste […] men folk kritiserer at nettleien er høy, og «uff, den derre nettleien, hvorfor må vi betale nettleie? Vi betaler jo allerede for kraften!» Det er vanskelig å forstå de sammenhengene (Ekspert 5).

I lys av tidligere forskning er det ikke overraskende at borgere beskrives i termer av kunnskapsunderskudd (se f.eks. Barnett et al., 2012). Den praktiske konsekvensen av en slik fortolkning av menneskelig rasjonalitet er en søken etter andre strategier som går ut over å produsere visuelle tilbakemeldinger og nye former for digital kommunikasjon.

En måte å håndtere dette på, som mange respondenter fremhever, er å innføre nye former for prissignaler. Et eksempel på dette er den planlagte innføringen av *effekttariff*. Effekttariffering muliggjøres av smarte målere gjennom hyppig automatisk avlesning av strømforbruk som viser hvor mye av den installerte effekten en husholdning bruker. Forskjellen mellom dagens løsning med energitariff og løsningen med effekttariff blir forklart slik: «… I dag har vi en energitariff, og du betaler for hvor mye strøm du bruker per måned, eller per år. Du betaler for energien. På effekttariff betaler du for hvor mye du bruker på én gang. Og hvis du bruker alt på én gang i en time, da får du en veldig høy strømregning» (Ekspert 1). Med motorvegmetaforen er effekttariffen noe som kan sammenlignes med en rushtidsavgift.

Effekttariffen blir et redskap for å økonomisk straffe høyt effektuttak. Har man anledning til å være «fleksibel» med strømforbruket, belønnes man derimot ved at straffen unngås. Hensikten er å oppmuntre forbrukere til et jevnere eller «flatere» strømforbruk, hvilket er i tråd med mange av våre informanters forestilling om menneskelig rasjonalitet som drevet av økonomisk nyttemaksimering. Informantene er også relativt samstemte om at den omfordelingen av kostnadene som en effekttariff legger opp til, er rettferdig. En informant sa:

> Hvis noen får lavere regning, så må noen andre få høy. Sånn er det. Og da er det også de som er mest fleksible som får gevinstene, og den som ikke er det som blir straffet i forhold til dagens fordeling. […] Det er vanskelig å se at det der skal være spesielt urettferdig hvis man enes om at det har en samfunnsøkonomisk gevinst som gir alle sammen en fordel (Ekspert 4).

Aktørene har altså tro på effekttariffer, og mener det er en rettferdig prismekanisme. Samtidig sa de at nye prissignaler må være kraftige for å fungere. En respondent sa: «Hvis ikke folk ser at de sparer store beløp, så er det ingen som gidder» (Ekspert 5). Straffen for «feil» strømforbruk må altså være hard, ifølge våre informanter. På samme måte som at mange peker på at informasjon ikke er nok, er det imidlertid mange som antyder at effekttariffer heller ikke vil produsere de ønskede endringene. Derfor vil mange ha tekniske løsninger som minsker kravene til menneskelig deltakelse og som delegerer fleksible valg til teknologien. Mange har tro på at vi i fremtiden vil se et forhåndsprogrammert hverdagsliv når det kommer til elektrisitet. Som en aktør sa:

> Nei, hvis man først skal ha teknologi inn og ha en form for styringssystem, så tror jeg det bør gå mye av seg selv. Jeg tror ikke vanlige folk, hva enn det er for noe, jeg tror ikke det at vanlige folk kommer til å ha lyst til å sette seg inn i eller gjøre noe aktivt i den sammenheng selv (Ekspert 5).

Mange knytter dette til styring av spesifikke teknologier i hjemmet, gjerne koblet til varmekilder (som varmtvannstank og gulvvarme), smart lading av el-biler eller nye typer avtaler med nettselskap som kan koble ut enkelte husholdningsredskaper ved behov. Ifølge en av våre informanter som jobber i et nettselskap (Ekspert 7), er betalingsvilligheten for komfort og letthet jevnt over høy. Man ser derfor for seg at dette er attraktive og lettsolgte løsninger og produkter for sluttbrukermarkedet.

> Som fremtidsvisjon er det knyttet størst håp til koblingen mellom strenge økonomiske incentiver og automatiserte valg. En av våre informanter forklarte entusiastisk hvordan man kan la kjøleskapet bli styrt av en tredjepart i bytte mot billigere nettleie, hvor byttet blir beskrevet som enkelt, gøy og prisgunstig: «Du som forbruker [vil] ikke merke noen ting, og da er det en lett deal, ikke sant? Du bare, ok, godtar at vi kobler på den her dingsen på kjøleskapet ditt, så får du billigere nettleie» (Ekspert 2).

I sum reflekterer aktørene i det tekno-epistemiske nettverket en debatt som har pågått lenge innenfor samfunnsvitenskapelige studier av energibruk: Hvorfor handler ikke mennesker i tråd med de teknisk-økonomiske målene for innføring av ny teknologi (Aune, 2007; Wilhite, 2008), og hva kan man eventuelt gjøre med dette? Resultatet i diskusjonen over er på sett og vis et håp om at det er mulig å få til en radikal endring av forbruket. På den ene siden er dette preget av troen på økonomisk rasjonalitet som drivende for adferd, og at det derfor er behov for kraftige prissignaler for å tvinge forbruket over i nye mønstre. På den andre siden er narrativet preget av et ønske om at de opplevde effektene skal være så små som mulig. Kombinasjonen av teknologi for automatisering og sterke prissignaler oppfattes å utgjøre et sterkt sett av styringsinstrumenter.

Den digitale fleksibilitetens hverdagspolitikk

Langdon Winner spurte i et berømt essay fra 1980 om teknologier har politikk. I denne artikkelen har vi så langt diskutert digitaliseringen av elektrisitetssystemet og de første skrittene på veien som er innføringen av smarte strømmålere. De umiddelbare konsekvensene kan virke små. Gjennom en analyse av hvordan sentrale aktører forstiller seg utviklingen, ser det også ut til at mange av aktørene ønsker at teknologien skal fungere som et sterkt styringsinstrument, samtidig som de opplevde effektene fra kundenes side skal være så små som mulig. I det følgende vil vi drøfte om det likevel er slik at disse teknologiene har en politikk, og hva slags politikk dette i så fall er. Videre er det interessant å studere hva de potensielle sosiale implikasjonene er av denne politikken.

På den ene siden er det opplagt at de teknologiene og løsningene vi har diskutert, er viktige i europeiske og norske politiske dokumenter. På retorisk nivå bobler disse tidvis over av beskrivelser om aktive forbrukere, engasjement og deltakelse via smarte energiteknologier og om et uutnyttet fleksibilitetspotensial. På den andre siden har vi aktører i forskning og industri som jobber med å omsette slike visjoner i praksis. Disse aktørene har et ambivalent syn på forbrukerne. De ønsker at forbrukerne justerer sitt forbruk ved hjelp av informasjon, men om dette ikke er mulig, setter de sin lit til nye effekttariffer og prisregimer. Videre, om disse heller ikke viser seg å fungere, setter de i stedet sin lit til automatisering, noen ganger i kombinasjon med de to andre virkemidlene (informasjon og pris). Her er det altså mulig å snakke om strategier for endring som strekker seg fra det liberale til det autoritære, og til hybride strategier.

Tidligere samfunnsforskning har observert en lignende spenning i det vi kan kalle ulike former for styringslogikk blant aktører som fremmer smart energiteknologi. Ballo (2015) viser hvordan teknologiene og ideene om fleksibilitet fra politisk hold ofte blir en del av en større neoliberal styringslogikk pakket inn i en økonomisk språkdrakt. Innenfor en slik styringslogikk er kvantifisering og måling helt sentralt, og forstås som å muliggjøre mer veloverveide, individuelle valg. Politikken blir slik en del av et større moderne narrativ, sentrert rundt individet som sentral figur (Aakvaag, 2006). Ballo (2015) viser imidlertid at bransjeaktører ofte forstår fleksibiliteten først og fremst gjennom å mobilisere et teknisk språk. I deres øyne er ikke de ovennevnte teknologiene ment å muliggjøre individuelle valg, de er styringsredskaper for å optimalisere ressursflyten i et teknisk system som elektrisitetssystemet.

Hvilke praktisk-politiske og sosiale implikasjoner er det verdt å diskutere i lys av den digitale transformasjonen av elektrisitetssystemet? Internasjonalt har oppmerksomheten rundt ulikt fordelte sosiale konsekvensene av slike teknologier vært økende i forskningen (Sovacool, 2017), som for eksempel har sett på konsekvenser for kjønnskategorier (Tjørring, 2016) eller ulike geografiske områder (Bouzarovski & Simcock, 2017). Forskningslitteraturen har generert en stor diskusjon om hvordan digitale informasjonsteknologier som er ment å endre vanlige folks energivalg utformes. Strengers (2013; 2014) påpeker at disse teknologiene har en tendens til å understøtte en spesiell form for maskulin habitus forankret i teknologiinteresse (se også Skjølsvold, Jørgensen & Ryghaug, 2017; Throndsen et al., 2017), noe som betyr at digitaliseringen av strømnettet kan være med på å forsterke en kjønnet arbeidsfordeling i hjemmet.

De sosiale implikasjonene av digitalt medierte prisregimer som for eksempel effekttariffer, har ikke vært diskutert. Det er imidlertid grunn til å tro at nye prisregimer vil påvirke hverdagslivet for ulike sosiale lag ulikt. Som vi så ovenfor, tas det til orde for en kraftig økonomisk sanksjonering av uønsket atferd for å oppnå forbrukerfleksibilitet. Dette er en problematikk som også enkelte av respondentene reflekterte rundt. For noen er det opplagt at løsningene de utvikler vil legge sten til byrden for dem som allerede sliter økonomisk. Som en av våre informanter sa:

> Inntekt, lønn, egen økonomi er viktig og betyr en del for hvor mye du orker å gjøre med det, eller hvor mye du vil bruke tid på [å tilby fleksibilitet]. Hvis det ikke betyr noe for deg økonomisk å spare, så gjør du kanskje ikke noe. Så har du andre som, hvis du kan spare litt på strøm og være fleksibel, så gjør de det [fordi] det er lønnsomt for dem, for de kan kjøpe mer mat i stedet. Så både antall personer, størrelse på bolig, hvor god tid man har og hvor god råd man har [har betydning] (Ekspert 1).

Noen eksperter reflekterer altså over hvordan effekttariffer kan slå ut og forsterke sosiale skiller. En annen respondent påpeker: «For disse her rikingene for eksempel, som bruker mye strøm, de vil nok ha helt andre motivasjonsfaktorer» (Ekspert 2). Denne diskusjonen peker muligens på et opplagt poeng. Effekter av å digitalisere strømnettet vil ikke distribueres likt i befolkningen. Teknologier, prismekanismer og nye organiseringsformer vil snarere slå ulikt ut og potensielt ha en uintendert sosial slagside. Vi ser lignende paralleller når vi ser på konsekvensene av økt fleksibilitet på andre områder.

Fleksibilitet er en sentral metafor i vår tid som gjerne har positive konnotasjoner og assosieres med muligheter til frie, individuelle valg, for eksempel når det gjelder å organisere forholdet mellom familieliv og arbeidsliv (Rantalaiho, 2009). Samtidig peker kritisk forskning på fleksibilitetens mulige skyggesider som økt arbeidsintensitet og en form for arbeidslivskolonisering av tidslommer som tidligere var forbeholdt privatliv (Felstead & Jewson, 2000). Et poeng som tydeligere kan relateres til vår diskusjon, er at behovet for fleksibilitet gjerne kommer fra en organisasjon som for eksempel har behov for fleksible arbeidstakere. Tidligere forskning har illustrert at det ikke er tilfeldig hvem som må tilby sin fleksibilitet for å få tilgang til arbeidsmarkedet. Kvinner i helse- og omsorgssektoren (Ingstad & Kvande, 2011), arbeidsinnvandrere (Friberg, 2015) og andre i lavtlønnede yrker, må særlig være forberedt på å tilby fleksibilitet for å få tilgang til de økonomiske godene som hører arbeidslivet til.

Digitaliseringen av strømnettet forflytter i ytterste konsekvens denne måten å tenke om forholdet mellom et systembehov og menneskers mulighet til å yte fleksibilitet, inn i folks hverdagsliv. Satt på spissen transformeres hjemmet til et tidsmarked hvor det å la være å utføre aktiviteter som krever elektrisitet, blir en salgbar tjeneste som kalles fleksibilitet.

Det kan bli dyrt å ikke være fleksibel, og de som er i en økonomisk utsatt posisjon, er nok også de som vil merke dette hardest. Videre henger muligheten til å tilby sin fleksibilitet sammen med mulighetene til å ta i bruk både ny informasjon og teknologi, noe vi vet ikke er jevnt fordelt i befolkningen. Smart energiteknologi er for eksempel sjelden utformet for å favne eldre mennesker (Barnicoat & Danson, 2015; Throndsen & Ryghaug, 2015).

I denne artikkelens innledning diskuterte vi at elektrisitetsforbruket i stor grad speiler samfunnets temporale rytme (Walker, 2014). Aktørene vi har intervjuet gjenkjenner denne dynamikken. Som én sa:

> Altså, man sover jo om natta, så står man opp om morgen, tar en dusj, så da er det en [last]topp. […] Så kommer folk hjem omtrent akkurat samtidig, så lager de middag, så får du en ny topp på ettermiddagen. Da kommer middagskoking, vaskemaskiner, oppvaskmaskiner og alt sånn (Ekspert 1).

Elektrisitetsforbruket speiler altså samfunnets rytme, og mye tyder på at konsekvensene av det digitale strømnettet også vil være med på å forsterke den eksisterende samfunnsdynamikken. I et slikt bilde vil noen (for)bli vinnere mens andre (for)blir tapere. Løsningene diskutert i denne artikkelen er foreløpig brukt innenfor rammene av pilot-, demonstrasjons- og utviklingsprosjekter. Etter som løsningene fremover gradvis blir en del av storsamfunnets energikultur, vil det imidlertid være viktig at utviklingen følges med et sosiologisk og samfunnsvitenskapelig blikk og at man forsøker å forstå også de uintenderte sosiale konsekvensene av utviklingen.

Diskusjonen i denne artikkelen peker mot at fleksibilitetspolitikken i norsk sammenheng handler om å transformere forbruk til beste for det som forstås som et relativt statisk elkraftsystem. Parallelt med dette foregår imidlertid en rivende utvikling innenfor småskala fornybar elektrisitetsproduksjon (særlig solceller) og batteriteknologi, og det er fullt mulig å forestille seg fremtider hvor samfunnets behov for krafttilførsel organiseres radikalt annerledes enn i dag, og hvor andre aktører får ansvar for å realisere fleksibilitetsbehov (se for eksempel Parag & Sovacool, 2016). Det er imidlertid et problem at teknologiutviklingen i norsk sammenheng ses på som politisk nøytral, til tross for at mye av utviklingen er tungt subsidiert gjennom forsknings- og utviklingsbudsjetter. Vi har tidligere pekt på at teknologiutviklingen ikke er nøytral, gjennom å vise at teknologi- og markedsutvikling på elektrisitetsfeltet er orkestreringsprosjekter som eksplisitt søker å endre sosial og praktisk dynamikk på ulike samfunnsnivå og felt (Skjølsvold et al., 2018). Vi ønsker oss med andre ord en utvikling hvor de politiske valgene gjøres eksplisitte og ikke kamufleres som «naturlig» teknologiutvikling. Dette ville kunne hjelpe oss i retning av nye former for eksperimentering med teknologier og organisasjonsformer som ikke nødvendigvis gjør strømkundene til syndebukker.

Konklusjon

Digitalisering betraktes av mange som selve nøkkelen til fremtidig vekst, velstand og problemløsning. Elektrisitetssystemet er intet unntak, og mange spår at digitalisering vil bringe med seg en bølge av disrupsjon som fundamentalt vil forandre forholdet mellom aktørene på feltet (f.eks. Parag & Sovacool, 2016). I denne artikkelen har vi sett på en liten og konkret, men for mange svært viktig detalj i fremtidens kraftsystem: forestillinger om «sluttbrukerfleksibilitet». Vi har vært særlig interessert i å diskutere de mulige sosiale implikasjonene av dette. Vi har studert hvordan aktører som produserer og promoterer «smarte» energiteknologier forestiller seg en fremtid preget av fleksibilitet, hvordan de betrakter menneskelig rasjonalitet og handling, og hvordan de ser for seg at nye teknologier kan være med å produsere fleksibiliteten. Teoretisk har vi trukket på forventningssosiologien og litteratur om forestilte brukere, for så å se på hvordan slike forestillinger blir performative.

Utgangspunktet for diskusjonen er utfordringer i elektrisitetssystemet som først og fremst handler om effekt. Fra et systemperspektiv bruker vi for mye strøm til samme tid. Vårt elforbruk er derfor et politisk anliggende, og målet er å endre det for å gjøre det jevnere. Digitale teknologier er sentrale i arbeidet, da de er nøkkelpremiss for strategiene som søker å transformere forbruket. Vi har sett at tre idealtypiske løsningsforslag dominerer diskusjonen: a) visuelle informasjonsteknologier, b) nye økonomiske virkemidler og c) automatiske og fjernstyrte løsninger.

De intervjuede aktørene har et ambivalent blikk på mulighetene digitaliseringen gir. De har tro på at teknologiene vil kunne være med på å transformere forbruket. De har også tro på at dette vil kunne gjøres på en umerkelig måte uten særlig sosiale konsekvenser. Vi har problematisert dette og antydet at ideen om sluttbrukerfleksibilitet i ytterste konsekvens innebærer at vanlige hjem transformeres til en tidsmarkedsplass hvor den sentrale varen er ikke-forbruk av elektrisitet. Som i arbeidsmarkedet, vil det antakelig ikke være en lik eller tilfeldig fordeling i befolkningen når det gjelder hvem som kan tilby denne formen for tjeneste og hvem som er avhengige av å tilby denne formen for tjeneste for å få de økonomiske hjulene til å gå rundt. I lys av dette er det i årene fremover avgjørende at utviklingen følges med et kritisk samfunnsvitenskapelig blikk.

Dette er en utfordring til teknologiutviklingsmiljøene, som bør åpne opp for samfunnsimplikasjonene av ny teknologi. De som finansierer forsknings- og innovasjonsprosjekter har et særlig ansvar for å kreve at nye perspektiver blir sentrale deler av finansierte forskningsprosjekter. Dette er imidlertid like mye en utfordring til sosiologer og samfunnsforskere, som tradisjonelt sett ikke har engasjert seg i teknologiutviklingsprosjekter. Vi kan ikke forvente at ingeniører selv gjør den sosiologiske jobben. Vi må derfor arbeide for å interessere dem, noe som betyr at vi må forske og intervenere mer på steder hvor teknologiutvikling har samfunnsmessige implikasjoner.

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6. 'Justice aspects of flexible household electricity consumption in future smart energy system' [4]

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.

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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).

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.

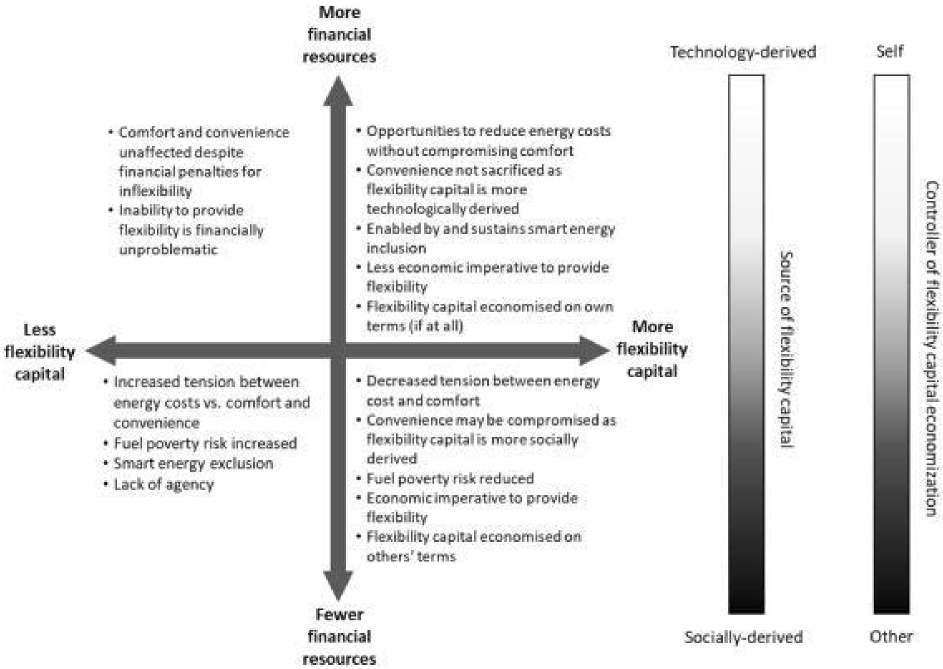

Figure 1. The interactions between flexibility capital and financial resources. Source: Powells and Fell, 2019.

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 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.

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

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 2: Interviewees, system 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 & 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 & 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.

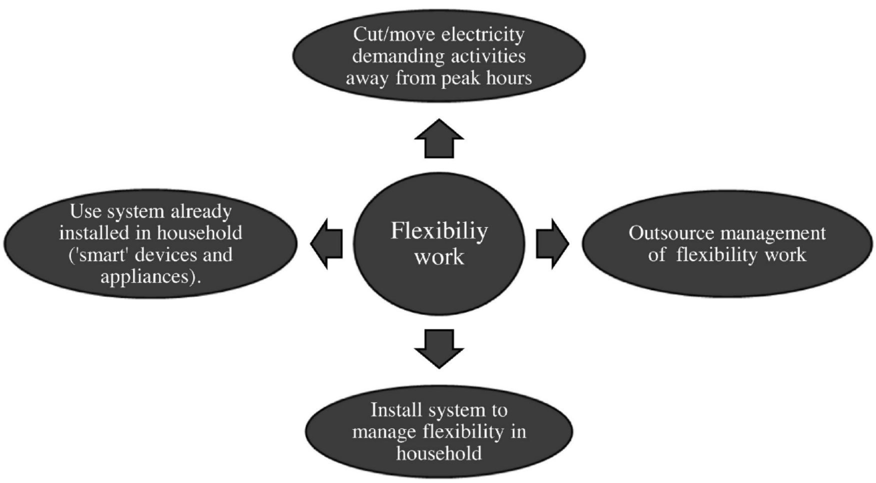

Figure 2: Typical ways of doing flexibility work in household.

5.3 Conflicting interests

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.

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 Figure 3.

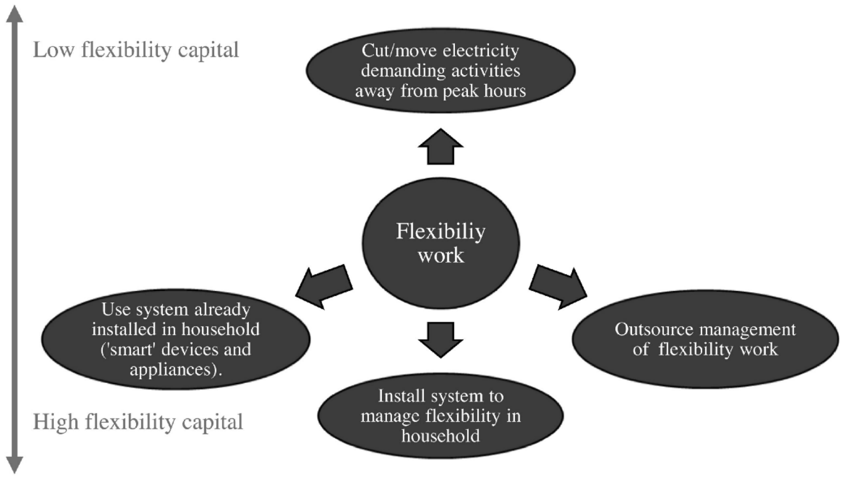

Figure 4: Options for doing flexibility work in household, considering flexibility capital.

Hence, in households with low flexibility capital, time and freedom in everyday life would be negatively affected if they are 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 & Brandth 2013). Norwegian couples disagree a lot about distribution of domestic work and economy (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 & 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 & 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.

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7. 'Flexibility poverty: "Locked-in" flexibility practices and electricity use among students'[5]

Abstract

The article provides a widened understanding of the concept of end-user flexibility and nuances the traditional individual-oriented approach often used in discussions on low carbon transitions. The authors draw on 75 narratives from of a group of end users that is often considered to be in a very flexible stage of life, namely students. They discuss the co-production of systems connected to material, structural and social factors that extend beyond individual willingness to be a flexible energy consumer. The article stresses that flexibility is shaped by living conditions, everyday life and social norms in particular ways that makes it hard to achieve for students and others living in shared households. The authors conclude that political incentives for low-carbon transitions typically exclude social groups such as students and other vulnerable groups in society, and hence may unintentionally create and reinforce what they term 'flexibility poverty'.

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1. Introduction

Climate change is said to be one of the biggest challenges of our time (EEA 2021; Kaygusuz 2010), affecting every country on every continent, disrupting national economies, and affecting lives (UN 2020). Solutions to tackle this challenge range from high-tech solutions (e.g., carbon capture and storage, solar panels, wind turbines, and battery technology) to encouragement of more sustainable choices in daily life for people in general (e.g., regarding what we consume, how we live, and how we commute) (Schwarzinger, Bird, and Skjølsvold 2019). The least efficient part of the global energy system comprises end users (Gilli, Nakicenovic, and Kurz 1996), yet there is great potential to impact carbon emissions through changes in end use (Grubler et al. 2018). However, sociotechnical changes to meet climate change is a complex issue, especially as industrial economies have become "locked into fossil fuel-based technological systems through a path-dependent process driven by the technological and institutional increasing returns to scale" (Unruh 2000, 817). In terms of end users' energy consumption, it is generally expected by policymakers and energy industry actors in Europe and beyond that that future consumers will have to be more active and flexible than they are today (Andrey et al. 2016; Ballo 2015). Such flexible consumption is understood as a key strategy to avoid power grid congestion by balancing supply and demand. This, in turn, can be achieved by reducing energy consumption during peak hours while also catering for increased electrification, for example in the form of new renewable energy production and transport electrification (e.g., Geels et al. 2017). Social science researchers who have studied schemes designed to instigate more flexible energy consumption point out that such efforts have often overlooked the heterogeneity of energy consumers, and that there tends to be a poor fit between such schemes and the practices of everyday life of consumers (e.g., Skjølsvold, Jørgensen and Ryghaug 2017; Schick and Gad 2015; Silvast et al. 2018; Strengers 2013; Torriti 2012).

To mitigate such concerns, scholars have explicitly studied how particular groups, such as the elderly (Barnicoat and Danson 2015) and vulnerable consumers (Shirani et al. 2020), reason about flexible energy consumption and use smart energy technologies. In this paper, we focus on different but distinct group of consumers, namely students. To our knowledge, this group has not been given much attention in previous studies of consumer flexibility. Within disciplines such as psychology, economics and political science, it has been common to study student populations as a proxy for wider populations. The generalizability of such studies may be criticized (e.g., Druckman and Kam 2011). Our interest in studying students as consumers is not to generalize from this group to the wide public, but rather to understand the specificities of students' life situation and how that relates to their energy consumption and possibilities for flexibility. We are interested in how students perceive their opportunities for engaging in flexible electricity consumption by either reducing or shifting their daily activities from peak load hours to other times of the day, which may be one way to achieve flexibility in energy consumption. Thus, the focal point of this paper is Norwegian students' energy consumption, and their experiences and perceptions of possibilities for the provision of end-user flexibility. On the one hand, examining these issues among students can generate valuable information about how this group of energy users' reasons about flexibility, as students are in a period of their life when they establish new habits and routines. On the other hand, analysis of a group of what may be "free and flexible" individuals can be a fruitful point of departure for broader discussions of inclusion, justice, and implications in low-carbon transitions, and the literature has called for work that looks more into how specific groups such as youth are affected by efforts to make energy consumption "smarter" (Robison et al. 2020).

1.1. Theorizing end-user flexibility

Flexibility provided by end-users tends to be described and understood in terms of ability to shift energy consumption away from peak load hours, which are times of the day when electricity consumption is high and the electricity grid is constrained. From a technical and economic point of view, this can be seen as means to utilize the power effectively and/or to avoid new investments in physical grid infrastructure (e.g., Lien et al. 2020). Thus, many actors have noted that understanding how to make energy consumption more flexible is regarded as increasingly important to manage electricity grids effectively and to enable wider energy transitions (Ballo 2015; Schick and Gad 2015; Smale, Van Vliet, and Spaargaren 2017; Throndsen 2017).

In discussions on how to make energy demand flexible, innovators and policymakers have tended to highlight at least three sets of tools or mechanisms as potential solutions: information, such as in the form of in-home displays (Hargreaves, Nye, and Burgess 2013); economic incentives, such as time-of- use tariffs (ToU) and critical peak pricing (CPP) tariffs (Öhrlund, Linné, and Bartusch 2019); and automation (e.g., Sæle and Grande 2011, such as direct load control (DLC). Both information and economic incentives are intended to change knowledge, awareness, and attitudes to stimulate active choices and new types of behavior concerning energy demand, whereas automation can be seen as a more technology-oriented pathway that outsources energy management choices to third parties to ensure that energy is consumed most efficiently (for a discussion, see Fjellså, Silvast and Skjølsvold 2021).

However, the three mechanisms for making energy consumption more flexible have yielded mixed results (for an overview, see Öhrlund 2020) and extensive criticism from social scientists, who have noted that they neglect the complexities of sociotechnical change and the deep temporal and contextual rhythms that shape everyday life and society (Shove 2003; Walker 2014). Furthermore, the design of the mechanisms has been criticized for being based on an understanding of affluence, technological competence, and interest as key components of human rationality (e.g., Strengers 2014), and neglecting the influence of social, cultural, and practical factors such as capital, age, and gender (e.g., Tjørring et al. 2018). Building on such critique and empirical observations, scholars have noted that economic incentives and information-based systems tend to generate only short-term interest and change (Hargreaves, Nye, and Burgess 2013).

With regard to the above-discussed types of criticisms, Blue, Shove, and Forman (2020) call for a reconceptualization of flexibility that more strongly involves critical reflection on the temporal structuration of society, and what it would mean to change the structuration in the future. Similar calls have also been made in the energy justice literature, where aspects such as social inequality in energy supply and demand have been questioned (e.g., Ingeborgrud et al. 2020; Jenkins et al. 2016; Powells and Fell 2019). In emphasizing flexibility in the energy justice perspective, the concept of "flexibility capital" has been launched to highlight that the unequal distribution of opportunities for providing flexibility across societies (Powells and Fell 2019). Homeownership, access to large electricity loads such as those generated by floor heating and electric vehicles, as well as economic capital entail opportunities for leveraging loads for flexibility purposes, as well as opportunities for opting out. Lack of both access to such loads and economic capital leaves few opportunities to provide flexibility and few opportunities for opting out. Thus, considering the way flexibility capital is unevenly distributed across society, Fjellså et al. (2021) argue that there are also unequal options for doing "flexibility work" for end-users with various types of flexibility capital.

In the next section, we discuss more how to theorize energy demand and flexibility issues with regard to students, before outlining our methods and analyzing how the co-production of systems connected to material, structural and social factors tie into students' energy flexibility.

2. Student life and energy use

Previous studies that have focused on young people's energy consumption have looked at energy and at information and communication technologies among youths (Christensen et al. 2014; Christensen and Rommes 2019); students living in fuel poverty (Kousis et al. 2020; Morris and Genovese 2018); and energy vulnerability (Bouzarovski et al. 2013). Scholars have found that students and young people are rarely recognized as a group vulnerable to energy poverty, and many students and young people do not recognize that they live in energy-poor conditions (Bouzarovski et al. 2013; Kousis et al. 2020). Energy poverty is broadly understood as the inability of households to maintain adequate levels of energy services at an affordable cost, and is caused by the interplay of low incomes, high energy need, and high energy prices (Doukas and Marinakis 2020). However, defining energy poverty poses a scientific challenge, due to different understandings and experiences (Sokołowski et al. 2020). Worldwide, it is estimated that 1.3–2.6 billion people experience energy poverty (Doukas and Marinakis 2020). Little attention has been given to energy poverty in Norway (Bredvold 2020), which is the empirical site of inquiry in this article. This is perhaps unsurprising, as Norway is considered an energy-affluent country, where most households spend a very low share of the house- hold budget on energy due to relatively cheap electricity prices and high standards of housing (OECD

2016). However, the increased focus on end-user flexibility, and the approaching introduction of new pricing schemes and tariffs in Norway, may change this (e.g., Skjølsvold, Ryghaug and Berker 2015**;** Christensen et al. 2020).

With regard to thinking about transitions in how energy is consumed, young adulthood is arguably a particularly important phase. Gram-Hanssen (2011) notes that this phase is characterized by socialization, in which social sanctions for violating norms, such as the norms of cleanliness, are strong. Hence, it is a phase in life when people are likely to become recruited as carriers of new practices (Shove 2009), which in turn is likely to affect how easy or difficult it is for them to be flexible in their electricity consumption. Some scholars claim that growing up in affluent households is associated with high energy use as adults, suggesting that practices of consumption are 'sticky' due to lived experiences in childhood and early adulthood (Hansen 2018). In line with this, Christensen and Rommes (2019, 82) claim, in their article on information and communications technology (ICT) and electricity use among youths, that "young people are adopting habits and practices that will be decisive for their future energy consumption." The practices that the youths engage in become embodied habits, forming their future everyday life practices. Thus, studying youths and young people may be a way of understanding future consumption and practices that will affect energy demand and flexibility.

However, student life is arguably typically quite different from that of both childhood and adult life concerning materiality, daily schedules, and social factors. A focus on materiality entails that we recognize the way material aspects of everyday life (e.g., housing conditions and available technologies) may be different for students compared with others. For example, students often live in housing of a lower standard compared with adults. Also, the temporal rhythm of students may differ from others, for example due to them having infrequent and varying time schedules of classes, part-time work, and not "nine-to-five" daily lives. Furthermore, the everyday social dynamics of student life differs from that in other life stages, for example due to poor economy and multiple students sharing living spaces while organizing separate daily lives. Thus, students are particularly interesting to study, as their everyday lives and routines might be less locked-in and structured by the requirements of society in general.

A handful of studies have focused on the way student life is linked to energy demand. For example, is has been noted that higher education constitutes an arena of invisible energy policy where the requirements that students face (e.g. concerning online presence) is part of an increasing overall energy demand in society (Royston, Selby, and Shove 2018; Wadud, Royston, and Selby 2019). Others point out that students often do not have control over or know their electricity expenses, that they have low incomes and give less consideration to electricity management than members of the general population (Cotton et al. 2020; Dulleck et al. 2019). However, the findings of social experiments in shared student housing suggest that students can both understand the concept of demand response, as well as engage in practicing flexibility in shared spaces (Higginson 2014). Also, electricity consumption in shared spaces, such as an elevator in a student dormitory, can be subject to demand-response schemes with some degree of success (Rotger-Griful et al. 2017). Students significantly contribute to energy demand, but because they often live, work, and use energy in different ways than other social groups, they are likely to be impacted by energy-related policies and developments in different ways than other groups of the public. For this reason, they are an important group to study.

In this article, elements from theories of practice, energy justice, and concepts of flexibility are combined to study end-user flexibility among students. Social practice approaches to social change, consider that social practices are important units of inquiry and analysis and that they represent a valuable aspect of sociotechnical change (Sovacool et al. 2020). In order to understand the potential for transformation of energy-related practices and flexibility among students, we use some of the insights from practice theories to study how materiality and meanings of end-user flexibility are co- produced with daily activities. Previous studies of energy consumption and flexibility have typically studied "traditional" households, consisting of one-family households (e.g., Skjølsvold et al. 2017; Hargreaves, Nye, and Burgess 2013). Such households create "internal systems" for daily activities, such as laundry and cooking. In this article, we take a different approach and examine what happens in households where multiple systems exist simultaneously. We discuss how students' daily routines relate to their work and studies, environment, living conditions, and other social factors in the organization of energy-related activities and the perception of flexibility. We address the following question: How do students' living conditions, daily life practices, and social norms affect their perceptions and abilities with regard to flexible energy consumption, both individually and collec- tively? Related to this, we also explore how students' ability or inability to practice flexibility relates to broader issues of energy justice, such as vulnerability to *flexibility poverty*.

3. The Norwegian context

In this article, we study aspects of flexibility among students in a Norwegian context. To situate the theoretical discussions mentioned in the preceding section, we give some brief insights into the Norwegian context in terms of the situation for students and in terms of energy. In Norway, just under 40% of the population in the age group 19–24 years was enrolled in higher education in 2020 (SSB 2021a), which is a relatively large proportion of the population. In some European countries, such as Italy, it is common for students to live with their parents; in Norway, this is only the case for 10% of students (Keute 2018a). Students are generally less likely to own a home, compared with non-students in the same age range (Revold 2019). However, it is common for students to live with others, such as partners, children, and peers, in student homes and diverse forms of shared housing. Only 12% of Norwegian students live alone (Keute 2018a). In Norway, as in the rest of Europe, students' living expenses constitute over 90% of their total expenses (Keute 2018b). However, it is difficult to know what proportion of their expenses relate to energy consumption, for two reasons: public statistical analyses, such as Statistics Norway, often exclude students as a group in national reports on energy consumption and expenses, and energy expenses are often combined and measured as "housing expenses" that also encompass housing loans/leases and energy (e.g., Barstad, Løwe, and Thorsen 2012). Even though one-third of full-time students have additional paid work (Keute 2017), 1 in 5 students (not living with their parents) reported that to some degree they struggled financially and had insufficient economic capital (Steffensen, Ekren, and Nygård 2015).

In terms of energy, Norway is an exception case, as almost all electricity is derived from renewable energy in the form of hydropower (e.g., Skjølsvold, Ryghaug and Dugstad 2013; SSB, 2019). Consequently, electricity is also used for heating in Norway, to a much larger extent than in many other countries. Household consumption of electricity is three to six times higher than the average household's consumption in the EU (Energifakta Norge 2019). Traditionally, there has not been much need for flexible consumption, but this situation is changing with the electrification of new sectors such as transport (e.g., Ryghaug and Skjølsvold 2019). Combined with an increasing role also for variable renewable energy sources such as solar power, this is placing new strains on local distribution grids and posing challenges for them, where flexible consumption is increasingly seen as part of the solution.

4. Methodology

In this article, we empirically draw on 75 illustrations and 17 written statements from 75 students, which we collected in 2018 in order to study electricity consumption and end-user flexibility in daily life. The students were taking courses in social sciences at master's degree level and bachelor's degree level (perspective course and one-year course), at a large Norwegian university. The numbers of students in the three categories were divided as shown in Table 1.

Table 1: Overview of students

Course	Number of students	Empirical material
Perspective course	41	Illustrations
One-year course	17	Illustrations + written statements
Master's degree course	17	Illustrations

The students varied in terms of age and life situations, and the students on the master's degree course were in general slightly older than the other students, ranging from being in their mid-twenties to mid-thirties, while the age range for the students at the bachelor degree courses (the perspective course and the one-year course) was from late teens to mid-twenties. Some of the older students at master's degree level lived in comparatively traditional households with their own families or with a few other adults, while the younger students at bachelor degree level more often lived with more people, and a few lived in their family home with their parents.

The recruitment process followed a procedure whereby students on the master's degree course and the perspective course were asked to participate in a practical task during a lecture. Based on their own experiences and their homes, they were asked to illustrate their energy consumption during an ordinary day as responses to the following four questions: (1) At what time of the day do activities take place in your home? (2) Are some appliances on 24/7? (3) what activities would be easy to move or cut? (4) What practices would be difficult to change? The students taking the one-year course were given a similar assignment to complete on their own, as part of the course training, in which they were asked to illustrate their energy consumption and include written reflections.

Together, the illustrations produced by the students formed an interesting and quite detailed account of the daily activities in their homes. Most of the students indicated what activities happened at what time, using drawings, numbers, text, or timelines. Some included the activities they perceived were flexible (easy to shift or cut) or inflexible (hard to shift or cut), as shown in Figure 1.

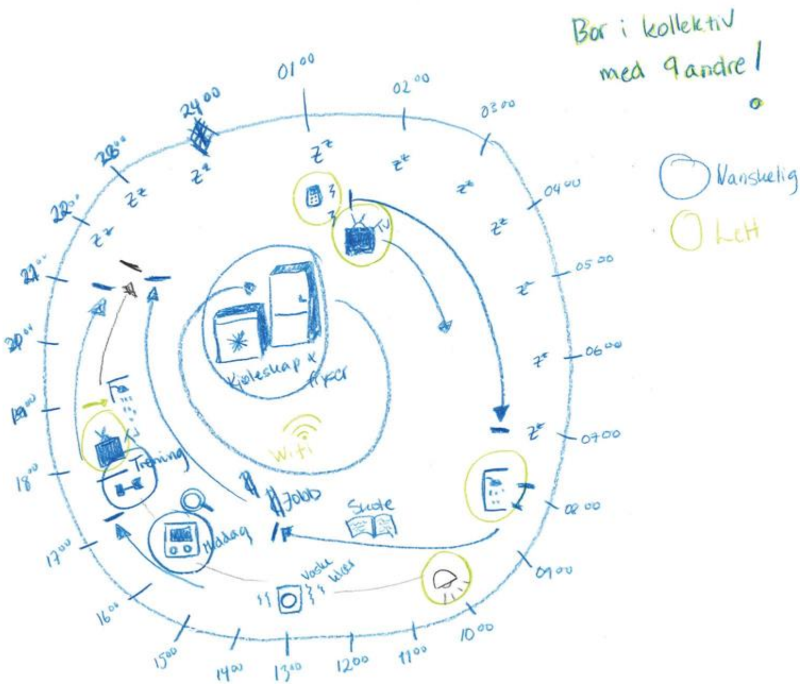

Figure 1: Example of a student's illustration of energy consumption regarding flexibility and inflexibility in daily life. The green text in the upper right part translates as 'Live in a collective with nine others!' The yellow circles (Lett) indicate what activities were considered easy to shift and cut (flexible) and the blue circles (Vanskelig) indicate what activities were perceived as complicated to shift and cut (inflexible).

When analyzing the data, we focused on the daily activities that the students indicated in their written words or illustrations were flexible or inflexible to shift or cut. We focused on three daily clusters of activities: (1) doing laundry, (2) activities to ensure personal hygiene (specifically showering), and (3) the use of information and communications technology. These activities were chosen as they were frequently mentioned in the empirical material and represented as more autonomous activities compared with other activities such as heating. As part of the analytical process, we quantified the material to gain an overview of what featured in drawings in terms of flexible and inflexible activities (the results are summarized in Tables 2, 3, and 4). In the following section and subsections, we present our analysis, focusing on how the students presented their energy-related activities and what activities they perceived as flexible or not flexible.

5. Flexibility in daily life

Based on the empirical material, energy-related activities were divided into three categories. The first category constituted activities shaped by societal structures, such as lectures and working hours, which were set by others than the students themselves. The second category comprised activities rooted in the materiality that surrounded the students, such as the standard of their housing, its design, and its facilities, which shaped how the students organized their daily life. The third category of energy- related activities consisted of activities shaped by more personal needs and comfort, such as cooking, cleaning, and leisure activities.

Activities that the students described as impossible, hard, or complicated to change, we refer to as 'inflexible'. Typically, inflexible activities were connected to studies and work, such as electricity used to run computers. Household installations that were often plugged in 24 hours per day (e.g., fridges, freezers, hot-water tanks, and Wi-Fi routers), were also perceived as inflexible. Many of the students also noted that the preparation of food was complicated to shift or cut. Most inflexible activities were explained as hard to cut or change due to practical reasons, but others were described as possible but undesirable to change for reasons of comfort and convenience. For instance, few were willing to sacrifice having a cup of coffee in the morning or having a fully charged mobile phone in the morning. Hence, inflexibility stood out as, not primarily as an individual choice, but as structured by societal temporal and material rhythms, in line with earlier studies (Shove 2003; Walker 2014).

The typical "flexible" activities were doing laundry, washing dishes, showering, entertainment, and charging devices and appliances. The activities that were perceived as flexible and "easier" to change in terms of time, place, and length, or even to cut altogether, were rooted in more personal needs or comforts, compared with those more directly linked to societal rhythms and structures such as work hours and study timetables. We also found that the material context of the home played a different role for the students than we have previously seen for more traditional single-family or occupancy house-holds (e.g., Fjellså et al.) because the students were more often renters, shared housing with others, and had low economic capital. The students described how they adapted to the standard of their housing, such as how cold apartments, lack of insulation, and lack of natural light were compensated by using extra heating, clothing, and electric lighting. One student explained that “Because the apartment is not particularly [well] insulated, the heating needs to be on all the time for it to be livable in the apartment.” The students seemed to adapt to the shortcomings of the material context of their household, and they worked around material constraints. The data did not reveal any sign of interest or willingness to make either long-term or short-term investments in their housing to improve its standard, and there were few objections against the few cases of housing of a low standard, probably because the situation was seen as temporary and hard to change.

In the following subsections, we focus on some of the activities rooted in the students’ personal needs and comforts. These activities were frequently reported as more autonomous than other activities, such as heating and cooking, which we found to be limited more by socio-material contexts. We focus on everyday activities related to (1) doing laundry, (2) showering, and (3) using ICT. These activities were perceived by many students as driven by individual preferences and needs, although the students differed in their willingness and ability to be flexible, and they raise questions of capital, social norms, morals, and safety.

5.1 Doing laundry

In Norwegian households, laundry is often done in the household and the majority of households own a washing machine (SSB 2012). However, students most often have to find a way to organize laundry as a personal activity, even when they live with others (i.e., non-family members). Many students indicated that domestic work in general, and doing laundry in particular, were flexible activities in terms of what time of day they could do it.

Figure 2 shows an illustration by a student who indicated that doing laundry (using a washing machine and tumble drier) could be moved to another time, in this case from the late afternoon or early evening to the morning.

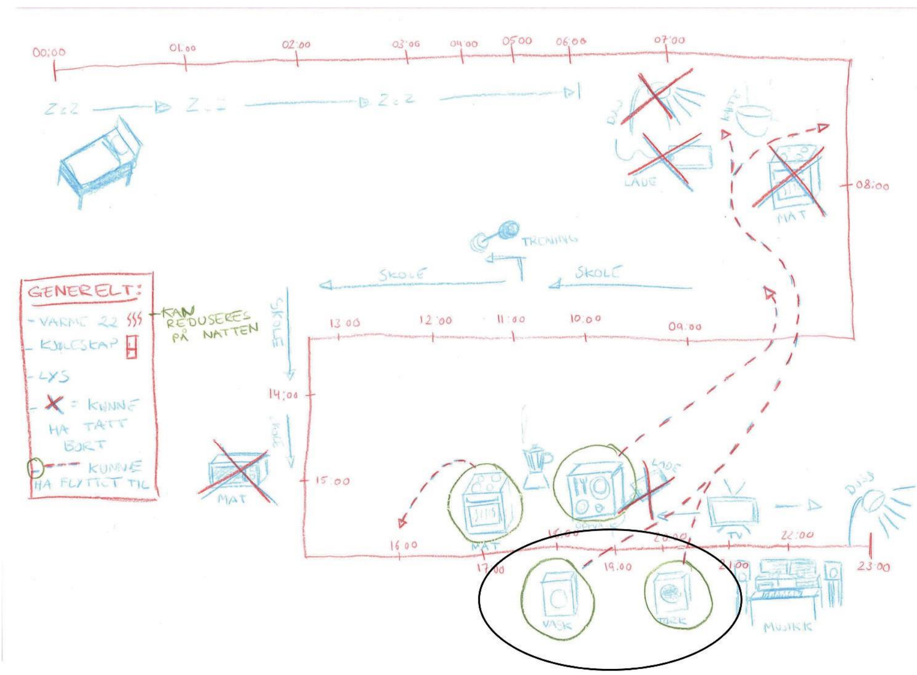

Figure 5: Student's illustration of a typical day, indicating that laundry (vask, tørk) was flexible and could be moved from late afternoon or early evening to morning.

The students' accounts of their flexibility potential concerning laundry are summarized in Table 2. About two-thirds of students indicated that they could be flexible with their laundry, while one- quarter mentioned that the activity was inflexible. Some marked their illustrations to show that they could wash less frequently, and others showed that they could do their laundry at other times of the day. In the case of the younger students (at bachelor's degree level), inflexibility was often indicated as a result of having to use washing facilities outside the home, such as a student laundry or joint laundry rooms. In that way, the inflexibility of doing laundry became particularly visible for those who had limited access to washing facilities, as the options for when they could do their laundry were very limited. Overall, the older students (at master's degree level) more often indicated that they were less flexible, including when it came to doing laundry, compared with other students.

Table 2: Summary of observations relating to laundry.

Observations	Flexible	Inflexible	Notes
Wash less	6		• Hard to move because washing is done outside the home, at a laundry • Wash during nighttime • Laundry is flexible in the morning and inflexible in the evening • Only wash dirty clothes • Laundry can be done in daytime when there are no lectures
Shift time	5		
Unspecified	12	12	
Tumble drier	4	2	
Total	27	14	

In the written statements, one student had a general view about when domestic work should be done:

> What day or time we mow the lawn, does not matter – the same goes for running the dishwasher, doing laundry, and vacuuming. When this happens is more about when it is convenient or when we can be bothered. (Student, living with partner in a house)

The student exemplified the view that is sometimes used to describe students' flexibility potential, namely that they have a large potential but are limited by convenience and lack of incentives. Another student explained his view on the flexibility of laundry activities as follows:

> The activity [of doing laundry] can in practice be done at any time, as long as you have some minutes available in between a couple of hours so that the laundry can be moved from the washer to the dryer and then collected again afterwards. (Student in student housing, who shared a kitchen and bathroom with three other students)

All students perceived laundry as a flexible activity, subject to available time between washing and drying cycles and when the laundry was finished, as indicated in the above the quotation. Their concern was mainly with clothes turning "bad" if they were left wet in the machine for too long. They also had to adjust to the availability of the washing facilities, as they were often shared with others, such as in shared apartments or common laundry rooms. There was an aversion to doing laundry during nighttime, due to concerns related to the fire hazard of appliances left running unsupervised and the inconvenience. However, compared with other findings from research on traditional householders (Fjellså et al.), the fire hazard element was much less problematized by the students.

One student wrote that a possibility for increased efficiency with respect to laundry within the household was to arrange to do his laundry together with his roommates' laundry, so that dirty clothes were collected from all roommates and washed jointly. However, for most students, doing laundry was seen as a highly individual task and therefore the student questioned the willingness of his roommates to be part of a collective washing scheme, as he expected it to be challenging due to highly personal preferences in terms of routines for cleanliness:

> There is an element of comfort when people do their laundry, as people wash their clothing at different temperatures and with different detergents. [. . .] People are also different when it comes to how comfortable they are with wearing the same pants or shirt over again. Some like to have newly washed clothing every day, while others can use the same shirt or pants for two or three days before cleaning them. Therefore, there are multiple factors to consider, which makes it harder [for students] to do laundry together. (Student, in shared house with five other students)

The above quotation touches on several issues of meaning, routines, and social norms of cleanliness, which is in line with previous studies that found that, on the one hand, individuals had their own definition of cleanliness, dirtiness, and the need to wash, while, on the other hand, definitions of cleanliness were shaped by culture and norms (which change over time) (Shove 2003). Thus, failure to comply with standards of cleanliness might imply a failure to sustain a central part of personal self- image (Shove 2003, 148).

In addition to finding available time outside work and study hours for doing laundry and having to be physically present in the house or laundry facility, the students had to engage in a social negotiation or contract with other householders or users of the washing facilities to find out when they could wash their clothes. Hence, the practice of doing laundry involved the capacity to navigate the system of laundry, other actors, and the materiality of the technology itself (e.g., the washing machine) and the clothes.

We found that the places in which students lived often consisted of multiple solo systems for doing laundry, which existing side by side and as part of a larger (laundry) system within the accommodation, which made flexibility more challenging compared with traditional single-occupancy or family households in which the provision for doing laundry often involves one system. Despite this, it is interesting to note that most students saw the washing of clothes as a flexible activity, which was also shaped by socio-material aspects that made flexibility more limited and 'locked-in' by various socio- technical structures, such as relations with other activities or actors co-existing in the same household. We found some similar tendencies when we studied experiences of flexibility related to showering practices.

5.2 Showering

As in the case of domestic work and laundry, the students were dependent on the availability of time, physical space (bathroom), and social interaction with others, in order to perform activities relating to personal hygiene. Students who shared living spaces with others expressed that they would use the shower when it was available. Unlike domestic work, showering had a clear element of comfort and interestingly it was often followed by a moral self-evaluation. This was found both in the written statements and in the illustrations as brief comments to the timeline (Figure 3).

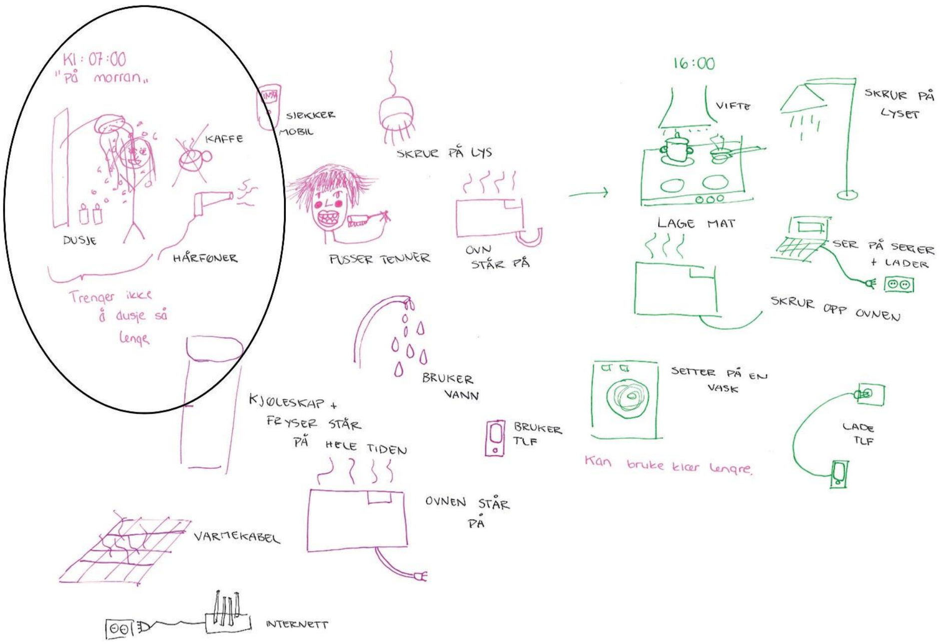

Figure 3: Student's illustration indicating that time spent showering could be reduced: "No need to shower for so long" (Trenge ikke å dusje så lenge).

Some students said they could shower at other times, at other places, or for shorter periods (Figure 3) or, less frequently, that they could be more flexible about their energy consumption. This was demonstrated in writing and illustrations, which are summarized in Table 3.

Table 3: Summary of observations relating to showering.

Observations	Flexible	Inflexible	Notes
Frequency	3		• Twice per day: flexible in the morning; inflexible after workout • Hard to change habits and electricity that one is dependent upon (e.g., phone, shower, food) • Hard to cut shower time in the morning • Shower in hot water a little too long
Length	8		
Change location	4		
Change time	9	2	
Unspecified	8	7	
Total	32	9	

One student pointed out that showering could not and should not be reduced too much, as this "could over time become socially problematic," hinting at societal norms of cleanliness and hygiene. Other students explained how showering in the morning was an important part of their morning routine to have a "fresh start" to the day and that moving the activity to other times of the day would be possible but would take away the pleasures related to the morning ritual.

Furthermore, the notion of cleanliness was ascribed more meaning than the activity of showering itself. It was infused with moral, social, and symbolic meaning, as previously suggested by Shove (2003). The moral self-evaluation penetrated the students' wording, through their use of terms such as "good," "could be better," or "being bad," when they illustrated showering routines.

One student wrote:

> I could be much better at taking shorter showers. Since I have electricity and hot water included in my housing contract, I have a tendency to take long showers because I don't need to think about how much hot water and electricity I use. [. . .] I see that I am so dependent on my routines and habits, that I am not willing to change much to reduce my electricity consumption.

Some students demonstrated a conflict between comfort and flexibility. On the one hand, they expressed awareness in terms of their flexibility potential, indicating that they had the option of taking shorter showers. They understood themselves as having flexibility competence, as they could envision a solution for becoming more flexible by changing the time, space, or length of time in which they took their showers. On the other hand, many students demonstrated hesitation toward changing their showering practices. Some clearly stated that they did not want to give up this element of comfort in their daily life. Thus, increased flexibility of shower routines would mean a reduction in comfort. For some students, not wanting to reduce their comfort level and hence being less flexible, meant they were not willing to give up something they thought that they ought to give up, particularly regarding the length of time they spent showering.

We found a similar moralistic self-evaluation in terms of the activity of charging devices during nighttime, in addition to what the students described as excessive use of indoor lighting and heating. This, too, was linked to comfort, but it was also presented as a consequence of practical considerations and convenience, such as compensating for lack of access to daylight or lack of adequate insulation in their housing.

5.3 Information and communications technology

Electricity for powering or charging information and communications technology devices (ICT), such as computers, TV, gaming consoles, and smartphones, was very important in the students' daily life (Table 4), as has been found in previous studies (e.g., Christensen and Rommes 2019). The students indicated a great flexibility potential with regard to TV and charging devices, especially charging cell phones during the night.

Table 4: Summary of observations relating to ICT.

Observations	Flexible	Inflexible	Notes
Charging, nighttime	11	6	• Phone charges usually during the night; dangerous (bad habit) • Habit of needing to be available and be entertainment if bored • Charge EV (electric vehicle) during the night, inflexible
Charging	5	2	• Charge when the battery is flat—conscious user of energy
Computer, daytime	3	8	• University, work; hard to change
Computer, afternoon/evening	6	6	• Hard to change due to homework
TV	15	4	• TV on for dog during daytime • Can cut and do homework—should be easy • The laptop serves the purpose of a TV.
Gaming console	2	1	• Do not want to move
Wi-Fi	1	1	• Always on
Total	43	28	

The multiuse of ICT devices, particularly smartphones and computers, blurred the lines between different types of use, such as for educational, work-related, social, and entertainment purposes. The multiuse situations also seemed to complicate the distinction between the flexibility and inflexibility of activities when a device was used for different purposes. The following statement is typical of the students' descriptions of computer use: “I use my computer for education, work, play, [and to] surf, and watch videos.” Computers were important for students to perform in education and work situations, be entertained, be educated, be creative, and to socialize online. Therefore, reducing or changing computer use could have affected the students’ academic, work, personal, and/or social life. However, a few students saw potential for flexibility with respect to the fact that they kept their computers turned on, even when not in use. One student with a desktop computer reflected on his flexibility potential as follows:

> I usually turn on the computer when I come home, and I often leave it on right until I go to bed. This is something I have done for many years, and it has become a habit. Ever since I bought a desktop computer it has become more and more a routine in my daily life that it is on, in my room when I am at home. [. . .] I can see that there is an opportunity to save energy only by changing my habit of always having my computer on.

Few students tended to find flexibility potential in their computer-related activities, as exemplified by the quotation above. Most students did not mention computers as something they could be flexible with at all, or they marked them as inflexible in their illustrations. The use of computers seemed to be regarded as especially inflexible during the daytime, as a consequence of rigid societal structures, typically related to work hours and education timetables that were outside the students’ control, as shown in Figure 4.

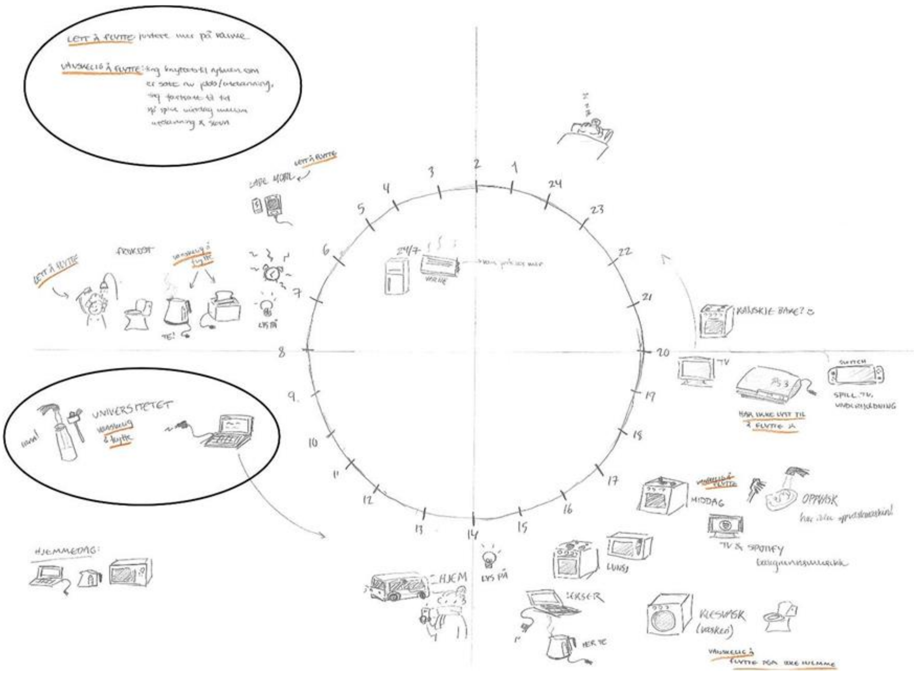

Figure 4: Student's illustration indicating that some activities are hard to move due to social rhythms: 'Hard to change: things connected to the rhythm of work/education, things that are determined by timetables. Must eat dinner between education and sleep' (Vanskelig å flytte: ting knyttet til rytmen av jobb/utdanning. ting fastsatt til tid. Må spise middag mellom utedanning & sovn). 'The university[:] hard to change' (Universitetet[:] vanskelig å flytte).

However, the students saw a much greater potential for flexibility in their device charging practices, as they recurrently mentioned this as something they could easily change (see Figures 1 and 2). We also found that the students moralized charging practices through statements such as "Phone charges usually during the night. Dangerous! (bad habit)" and "it [mobile phone] charges at night, which is a bad habit that I will try to change so I can charge it when I am awake," as they associated nighttime charging with a fire hazard.

Some students not only moralized their charging practices, but also rationalized their choices by explaining the need for fully charged devices in the morning, despite the perceived fire hazard of nighttime charging. The convenience of a fully charged phone meant access to, for example, music, information, entertainment, making payments, and education:

> I charge my phone during the night, and then it lasts all day without being recharged. Charging the phone is not good for many reasons. Unnecessary energy is spent when having it connected to the charger for such a long time, while it at the same time is a major fire hazard. [. . .] I use it [the phone] all the time to listen to music, surf online, check the bus schedule, and a lot more. Since the phone is used so frequently during the day, I find it hard and impractical to put it down for charging in the middle of the day.

In the practices relating to ICT devices, we found that the activities linked to the direct use of the devices (such as using a laptop for university work) were less flexible than the practices that enabled their direct use (such as the charging of a laptop). TV screens can be replaced by alternative screens, while computers were inflexible because many used their computers at all times for different activities during the day, which made it problematic to turn off. The students' inflexibility concerning the use of computers seemed to be shaped by societal structures, reaching beyond the students' willingness and abilities.

6. "Locked-in" flexibility

The concept of 'lock-ins' are often used to describe mechanisms that constrain new alternatives due to path-dependence increasing returns to scale, even when alternatives are known to be cost-neutral or cost-effective (Arthur 1994). The term has also been used in studies of energy policy and climate change, such as Unruh's study of carbon lock-in, which illustrates how difficult it is to get rid of fossil fuels (Unruh 2000). One way of interpreting the introduction of flexible energy consumption, is as an effort to break the locked-in patterns of past electricity consumption, from the metaphorical societal shackles that leads to the production of peak load consumption.

In doing this, however, designers of mechanisms and incentives that seek to stimulate flexibility should be aware that as we open up new paths we might also run the risk of producing new path dependences and lock-ins. Building strong policies, investments, and tariffs in this direction without an eye to unanticipated consequences may result in locked-in pressures on individuals and social groups to participate in the energy system by providing flexibility. If done in a non-reflexive way, this might reenforce existing patterns of inequality across society, hence contributing to the further entrenchment of such patterns. For individuals who have low “flexibility capital” (Powells and Fell 2019), a path with strong incentives for providing flexibility might paradoxically result in less flexibility with respect to how to live and everyday life, despite the energy consumption becoming more flexible from the perspective of the energy system. Such dynamics might also contribute to the production of flexibility poverty.

In this article we have identified multiple ways of being flexible, and many mundane under- standings of flexibility. When looking at individual activities, we found that the willingness and ability to act flexibly were demonstrated by many students. The students showed potential to be flexible in terms of how often, at what time, the place, or length of their energy-intensive activities with regard to the consumption of electricity. Individually, many students demonstrated a potential for flexibility. However, collectively, the students’ flexibility potential was limited due to socio-material factors, such as housing, life situation, and limited flexibility capital. This might also be thought of as a form of lock- in. We suggest that some social groups, such as students, may be living, temporarily or permanently, in a situation of flexibility poverty, where there is little room to maneuver flexible energy consumption and the flexibility potential that does exist becomes constrained and “locked-in” by other activities and people.

Promoting end-user flexibility in the general population through a variety of flexibility mechanisms as a response to increased electrification and electricity consumption at critical peak hours may coincide with basic needs in social groups that are vulnerable to flexibility poverty. For example, incentives intended to target owners of electric vehicles to charge their vehicles outside peak hours may create difficult situations in crowded student homes, where the possibilities to do energy- intensive activities, such as cooking and cleaning, are limited. Previous studies have demonstrated that the potential to be flexible in the household is dependent on flexibility capital, and there are different ways of doing “flexibility work” in households based on the flexibility capital (Fjellså et al.). Individuals with low flexibility capital have fewer options within the scope of flexibility work, hence leaving some with the only option of doing flexibility work manually. We found that this was the typical option for the students in our study, and hence it increased their vulnerability for flexibility poverty.

Also, students are a social group that is often sidelined as a target for energy policies and planning, which tend to target the general population. Economic subsidies for private persons are typically directed at owners of homes and vehicles, to improve energy efficiency efforts by, for example, installing solar panels, improving insulation or heating systems in the home, or by switching from fossil fuel based vehicles to electric vehicles. For instance, in Norway, the public energy authority, ENOVA supported 20,000 energy efficiency projects in Norwegian households through a budget of over EUR 33 million (ENOVA 2020). However, it is likely that relatively few of those who benefited from the support schemes were students, as only 1 in 10 students owns the house or flat in which they live (Revold 2019), whereas in the general population 8 out of 10 are homeowners (SSB 2021b). Housing standards have been found generally poorer for those who rent compared with those who own their homes (Normann 2016), and renters typically own less energy efficient technologies (Krishnamurthy and Kriström 2015). This demonstrates a distributional bias in public support, whereby some social groups – primarily private homeowners – are more favored than others.

In analyses of low-income households and poverty, it is common to exclude students based on the “specialness” and temporality of their life stage (e.g., With and Thorsen 2018). Such a view emphasizes that students are perceived as a special group outside mainstream society, potentially making it easier to overlook or dismiss students as stakeholders or as affected by energy policies. Others living in untraditional housing situations and being in temporal life situations may also be less targeted and outside the scope of policies, which are mainly targeted at the “traditional” end-users. Thus, being in an “untraditional” living or life situation may cause one to be more exposed to flexibility poverty. On the one hand, access to and ownership of housing and technology are essential to act flexibly with energy consumption. On the other hand, the absence of flexibility capital, and thus being flexibility poor, might be a steppingstone toward energy poverty, as structural dynamics and incentives increasingly applaud flexible energy investments and practices. Hence, we notice that current energy policies promoting more flexible energy use, the absence of flexibility capital, and experiences of flexibility poverty, indirectly may reinforce and cement already existing mechanisms of inclusion and exclusion in ways so that disadvantaged and vulnerable social groups are hit even harder. Thus, transitioning toward low-carbon societies and mitigating climate change through flexibility require the attention of policymakers and system developers to limit energy and flexibility poverty.

Insights into the effect of social, structural, and material factors in abilities for flexibility are key to unpacking the complexity of end-user flexibility. Thus, the inclusion of narratives, including those living in untraditional housing situations or who are in temporary stages of their life, such as students, broadens the understanding of end-user flexibility and opens discussions for potential structural and individual consequences.

7. Conclusions

In this article we have demonstrated how students perceived and understood flexible energy use in their daily life. We found that their individual energy consumption was generally understood as flexible but was limited and "locked-in" due to daily practices and schedules, other people co-existing in the same household, and systems of practices existing side-by-side. The variation in how flexible the students understood themselves can be explained in terms of how the students gave meanings to the different activities and what those activities represented in their daily life. For some, a shower in the morning was the same as a shower at any given time, while for others it represented a morning ritual that gave them a fresh start to the day. Collectively, the students described and illustrated a situation in which they, as a group, generally had little flexibility available, and in which the flexibility they did have would directly impact their comfort levels or how they needed to reorganize their daily life, if acted upon.

In this article, we have also discussed the implications of "locking-in" flexibility on an individual and structural level. We have argued that a narrow focus on end-user flexibility may cause a lock-in of flexibility and consequently create path-dependency, thus also creating inflexibility among some social groups of end-users, especially leaving those in temporary housing or in temporary stages of life to become more exposed to flexibility poverty. In this article we propose flexibility poverty as a term to describe how some people have limited capital, capacity, time, and space to act on their flexibility, and thus have limited alternatives within flexibility work. We believe those who are "flexibility-poor" may be more exposed to a situation of energy poverty, particularly if flexibility becomes a commodity.

From an energy justice perspective, energy policy and innovations aimed at low emission transitions should not come at the expense of potentially vulnerable groups and should not create and reinforce a situation in which some social groups of end-users systematically live their daily life in flexibility poverty, irrespective of the temporality of their life stage and situation. Therefore, we encourage energy flexibility regulators to consider the importance of distributional bias in public support for energy efficiency measures and to be aware of the implications of "locking-in" flexibility.

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8. ‘Flexible energy cultures? How accelerated energy transitions and flexibility needs affect the understanding of energy consumption amongst Norwegian households’[6]

Ingvild Firman Fjellså and Tomas Moe Skjølsvold

Abstract

‘Smart’ and flexible electricity consumption are becoming increasingly important to reduce peak electricity demand, cater for societal electrification, and mitigate climate change. This article studies domestic electricity consumption and end-user flexibility in Norway, as part of, and affected by unfolding energy transitions. Based on household interviews, the authors examine energy-related household consumption in terms of flexibility and rigidity. Findings are discussed through the lens of energy cultures frameworks by addressing how norms, practices, material culture and external influences affect electricity consumption and flexibility. The article also discusses changes in Norwegian energy cultures from the 1990s by drawing on previous works. Findings indicate that Norwegian electricity end-users have shifted toward a ‘sparse’ energy culture, as values, norms, energy efficiency efforts, and daily practices are aimed at a modest consumption. The authors conclude that policy makers and industry should consider energy cultures in their work to promote a more flexible domestic electricity consumption.

This article is awaiting publication and is not included in NTNU Open

[6] Under submission

9. Cross-cutting analysis

Thus far in this thesis I have studied end-user flexibility in electricity consumption from socio-technical perspectives. I have analysed expectations and visions of the role of users in the future energy system and end-user flexibility, domestic electricity consumption, and energy justice implications. Paper 1 studies experts' envisioned flexibility solutions to accommodate economically rational, disinterested, and uninformed end users. Paper 2 argues that different end users have different possibilities to consume electricity flexibly, which can create or reinforce social injustices. Paper 3 addresses how some social groups, such as students, in temporary life stages and living situations, are more prone to being flexibility poor as their flexibility potential becomes locked in. Paper 4 demonstrates how electricity consumption is driven by societal temporal rhythms, routines, and technology design, which in many cases are hard to change. In this part of the thesis, I bring aspects from the research papers into a broader discussion to answer the overarching research questions: *How is flexible electricity consumption shaped by expectations, energy culture, and everyday practices? What are the energy justice implications of end-user flexibility?*

I start by discussing experts' expectations with regard to domesticating end-user flexibility in terms of the symbolic, cognitive, and practical domestication dimensions, and how this relates to energy cultures. I then discuss experts' flexibility visions, and how their expectations may have unfair and unjust consequences. Thereafter, I address the everyday aspects of consumption and efforts needed in order for people to consume flexibly, and how this has implications for whom can participate in energy transitions. I end my discussion by arguing that end-user flexibility can be understood as a way of delegating labour and responsibility away from the energy system and onto the users.

9.1 Expectations with regard to domesticating end-user flexibility

My research for this thesis focused on householders' electricity consumption and expectations with regard to more flexible consumption, and the findings presented in the preceding chapters offer insights into energy-related activities and technologies used in Norwegian households, and reflections on changes in such activities and the use of technologies to reduce consumption at peak hours. In this context, domestication theory is useful because it can be used to explore expectations regarding more flexible electricity consumption by discussing what electricity is used for, what it represents for users, and what changes in consumption might mean in daily life for users.

Drawing on domestication literature as developed by Sørensen and colleagues (Berker et al., 2005; Lie & Sørensen; 1996; Sørensen et al., 2000; Sørensen, 2005), domestication can be studied in terms of three dimensions: practical, symbolic, and cognitive. The aforementioned authors emphasize that domestication is an ongoing process, and that artefacts can be 're-domesticated' if they take on new roles or 'dis-domesticated' if they are removed. Through this lens of domestication, experts envisioned that end-user flexibility would be domesticated primarily in terms of the cognitive dimensions, meaning that they thought users' flexibility would depend on whether or not they (the users) understood that it would benefit them economically. This expectation rests on the premises that end-user flexibility is possible in practice and that users are economically rational. Such views have long been criticized by SSH scholars specializing in energy (e.g. Aune, 1998; Christensen et al., 2020; Darby & McKenna, 2012; Hargreaves et al., 2013; Ingeborgrud et al., 2020; Lutzenhiser, 1992; Ryghaug & Sørensen, 2009; Strengers, 2014; Wilk & Wilhite, 1985). Nevertheless, the view that users will change consumption if they gain more knowledge and find it cost-beneficial is evidently still holding ground.

Moreover, for the end users, the findings from my research suggest that practical, cognitive, and symbolic dimensions are equally important when they reflect on domesticating end-user flexibility. In Papers 2, 3 and 4 it is shown that users made sense and meaning of electricity and flexibility in various ways. As exemplified in Paper 3, a shower in the morning represented something more than water over the body: it represented a refreshing start of the day and a familiar, comfortable ritual – a sensory experience. The case of reducing electricity consumption in the morning peak hours by, for example, showering at another time of the day on a regular basis can be seen as a 'redomestication' of the practice of showering. Technological and social developments can spur redomestication processes when the meaning and role of technologies or artefacts are altered due to changing circumstances (Bertel & Ling, 2014; Grošelj, 2021; Sørensen, 1994). In the case of showering, the shower can take on a new role as a flexible resource in the household by not being used during peak hours. For the electricity user, changing showering routines would include a change in the practical, cognitive, and symbolic dimensions related to the shower, for example through developing a new personal hygiene routine, thereby symbolically creating meaning and identity for a new routine, and cognitively gaining and exchanging knowledge about the new showering routine. As such, it is probable that domestication of end-user flexibility mechanisms and incentives will depend on what electricity consumption and end-user flexibility represent for users across all three domestication dimensions, and how these dimensions are intertwined with and affected by 'energy cultures' made up of norms, practices, material culture, and external influences (Stephenson et al. 2010; Stephenson et al. 2015).

Paper 4 shows that energy cultures are dynamic, and that there has been a development in Norwegian energy culture in recent decades. In Aune's categorization of Norwegian energy culture in the 1990s electricity users were represented in all of the following categories 'enjoying', 'sparsely enjoying', 'hesitantly sparse,' and 'sparse' (Aune, 1998). My co-author and I found that in 2017/2018 domestic electricity users mainly fell into Aune's energy cultures category 'sparse' which was because the consumption of electricity was done with consideration for not wasting resources and by implementation and/or use of energy efficiency means. The discussion suggests that many traditional householders considered their flexibility potential as limited to reducing additional heating and lighting in the household and moving the use of household appliances to other times. Beyond that, rearranging daily life routines considerably or investing heavily in flexibility technologies to reduce consumption at peaks, or in energy efficiency measures to lower overall electricity consumption entirely, was impossible for some householders and for others considered possible, but highly inconvenient. The possibilities were linked to the householders' available financial means and life situation.

Reflections on taking additional actions were mirrored in the householders' energy cultures. For instance, norms and ideologies such as environmental considerations or acting in solidarity with their community were important for the users' willingness and motivation to engage in end-user flexibility. Material culture and practices were important for the householders' abilities to domesticate end-user flexibility in daily life in a convenient way. In this regard, factors such as the type and standard of household, access to flexibility technologies, daily schedules, work, and family situation were important.

External influences, such as policies and price signals, influenced the end-users' energy cultures based on what the influences meant to them symbolically, cognitively, and practically. As an example, for some, a price signal meant an extra, unproblematic expense, while for others it meant an additional push toward shifting consumption over to night-time, despite the added fire risk, or reorganizing their work schedules by, for instance, taking on more night shifts. The elements making up an energy culture mutually influence each other (Stephenson et al., 2015), and, as demonstrated above in this subchapter, this became visible when the householders reflected on domesticating end-user flexibility.

Having discussed experts' expectations regarding the domestication of end-user flexibility in terms of the symbolic, cognitive, and practical dimensions, and how this relates to energy cultures, I next turn to the matter of experts and their visions for end-user flexibility.

9.2 Flexibility visions

As discussed in Paper 1 and Paper 2, experts envisioned users as having knowledge deficits, lack interest, and being economically rational. Therefore, information about benefits related to end-user flexibility, economic incentives, and automated flexibility technologies were considered appropriate solutions to accommodate those characteristics. The flexibility solutions were additionally framed as fair and neutral, as they would be the same for all electricity users. Expecting users to be disinterested, uninformed, and economically motivated is neither uncommon nor controversial, as is also the case with the proposed solutions. Such views and solutions are recognized as dominant in energy policies and in previous studies of smart grid projects (e.g. Ballo, 2015; Hansen & Borup, 2018; Throndsen, 2017). They are also in line with Van Lente's 'lessons' of sociology of expectation, which claim that expectations about the future build on preexisting assumptions that are reproduced within networks (Van Lente, 2012).

How experts configure users, frame the public's capabilities and motivations, and script and develop solutions has some important implications for energy justice. First, like technological artefacts, we may see flexibility solutions and incentives as holders of ‘scripts’ (Akrich, 1987, 1992) that are based on designers, developers, or even policymakers’ assumptions about the future users. When expectations are brought into design and developments processes, the final product will be influenced. For example, a price signal or an automated flexibility technology will be inscribed with expectations about users’ interest, motives, competencies, and limitations, with the intention of encouraging or discouraging certain types of use. Thus, ‘boundary work’ (Woolgar, 1990) is purposively involved to limit unwanted use or behaviour. In the absence of consideration of the implications of inscribing expectations into flexibility solutions will have for users in the use situations, harmful consequences may occur. In terms of end-user flexibility, a negative consequence of implementing solutions based on a narrow set of user characteristics, such as economically rational, competent, and resourceful user – a ‘resource man’ (Strengers, 2014) – can be the exclusion of social groups that do not fit with such user descriptions. Feminist and STS scholars, (e.g. Star, 1991) have emphasized the importance of paying attention to the diversity of users and the power relations among actors involved in technology developments, because users will hold different positions in relation to technology (Oudshoorn & Pinch, 2007).

Second, when solutions are mainly aimed at ‘activating’ passive consumers through means of economic incentives, automated flexibility technologies, and information, they are also oriented toward individuals rather than toward social structures that reinforce temporal consumption patterns. A typical example of such temporal structures is the organization of the labour market and family life, where much of the labour force works in set hours – in Norway, typically from 8 a.m. to 4 p.m. – and after school’s extracurricular activities finish and kindergartens close, shortly afterward. Consequently, electricity consumption follows this societal rhythm and can thus be described as a ‘social base load’ (Wilhite & Lutzenhiser, 1999), due to demand for energy to perform regular routine activities, such as cooking, cleaning, and heating, around those hours. This differs from what Wilhite and Lutzenhiser (1999) describe as a ‘social peak load’, which occurs when energy consumption rises due to social events and activities, such as when guests visit for dinner or a party. Moreover, the challenges with an individualization of a structural issue, such as peaks in the electricity grid, is that a variety of relational, societal, institutional, and material factors may hinder groups of people from engaging and participating in end-user flexibility. Such factors can be shaped merely by the organization of society, such as the division of labour, caretaking and domestic responsibilities, access to technologies, social inequality, or lack of supporting policies, which may make end-user flexibility challenging to achieve. When expectations about changes in consumption are framed as possible to fulfil but hard to achieve, it can foster feelings of discouragement and inadequacy among the public, as observed among Norwegian householders by Aune et al. (2016), who found that they were concerned about energy consumption but were unable to act upon their concerns.

Third, when flexibility solutions are framed as neutral and fair for reasons that all are treated the same, such as being given the same price signal or the same opportunities to engage with flexibility technologies, no consideration is given to variations among the users in terms of factors such as power relations, access to capital, capacity, time, and materiality. This understanding is in line with the notion of 'equality' rather than 'equity'. According to Loefler (2006), equality emphasizes evenness and lack of difference, while equity emphasizes fairness: 'what is fair is not necessarily equal, and what is equal is not necessarily fair' (Loefler 2006, p. 735). Thus, flexibility solutions, such as price incentives or flexibility technologies, can be equal for all, but they will not necessarily fair and/or neutral, because the efforts needed to achieve a certain goal (in the case of this thesis, end-user flexibility), will come at a much higher cost for some than for others. Thus, limitations inscribed in flexibility incentives or technologies will be stronger for some than for others, as some users will have the capacity and capital to either ignore or adjust to the boundaries, such as by investing in smart energy management or solar panels, or only paying for the added energy costs of comfort and convenience. Hence, the strength of limitations inscribed in flexibility technologies or incentives will vary between electricity users, based on the users' capital and capacity. A related example is how the COVID-19 pandemic has been an inconvenience for all but has provided some social groups with additional burdens, such as victims of domestic violence, vulnerable youths, low-income households, and front-line workers, despite living under the same regime.

The implications of the role of expectations for end-user flexibility, such as scripting, narrow user characteristics, individualization of structural issues, and framings of fairness and neutrality, as outlined above in this subchapter, raise concerns related to justice and fairness. The concerns touch on the three core tenets of energy justice: distributional justice, recognition justice, and procedural justice (e.g. Jenkins et al., 2016; McCauley et al., 2013), in addition to epistemic justice (e.g. Kidd et al., 2017; Valkenburg et al. 2020), as shown in Table 4. When viewed through the energy justice lens, these concerns indicate lack of inclusion and exclusion in decision-making processes (procedural justice), that some expert networks are recognized as knowledgeable and thus have the power to define issues and solutions (epistemic justice), that burdens and benefits may be unevenly distributed (distributional justice), and that social groups of users become affected, misrepresented, or ignored (recognition justice).

Table 5: Implications of experts' expectations regarding end-user flexibility in electricity consumption

Issue	**Implications**	**Energy justice dimensions**
Scripting based on bias and narrow user characteristics	Does not consider variation among users and the influence of designers' expectations in design. Does not problematize the power in terms of who is delegated the responsibility to define and develop solutions.	Procedural and epistemic
Individualization of solutions	Shifts responsibility away from the system and towards individuals. Does not consider the social and cultural context of users, such as work and family life, which reinforce consumption patterns.	Distribution
Solutions framed as fair and neutral	Fails to recognize that equal treatment does not provide equal outcomes. Does not consider variations among users' capacity and capital to engage with technologies or act on incentives, where some must make more efforts than others to achieve the same goal.	Recognition

Rather than taking a critical approach to expert networks framings and expectations toward users and criticizing the lack of consideration for the various aspects of energy justices, an alternative route to approach end-user flexibility is to look at the organization of knowledge production. For instance, Jasanoff (2018, p. 14) advocates a holistic and humble approach to energy policy:

> What we lack most in current energy policy debates are methods for connecting the *is* and the *ought*. For too long, we have delegated the tasks of observation and

> analysis to expert communities without challenging their framing assumptions and even the values that guide their methodological choices. The challenge for tomorrow is to reintegrate the sciences of the state we're in with a more inclusive debate on where we should be going as a global community. This is not a task for science alone, and certainly not for inventors alone, but for politics, ethics, and activism—animated by a more enlightened view of the limits of what we know, and a more humble approach to what is possible, given those gaps and omissions in knowledge.

Taking inspiration from Jasanoff, I would argue that a more humble and holistic approach to end-user flexibility is key if we want to achieve energy flexibility in a just way. We need to open 'black boxes' and address the questions of how knowledge is produced and by whom and why, what is the current state, what is possible, what do we have knowledge about, where do we lack knowledge, and where should we go as a community. By doing this, we could pursue a more reflexive approach to issues such as biases, individualization, knowledge gaps, and the social costs and consequences related to the scripting of flexibility technologies and incentives, and thus open up for more inclusive debates about fairness and justice in energy policy.

In this thesis, my aim is to contribute to a more humble and holistic approach to end-user flexibility by opening some of the 'black boxes' concerning electricity consumption and flexibility. Accordingly, I have included a variety of electricity users' perspectives, addressed users' stories, worries, reflections, and daily lives, discussed energy cultures, and discussed justice implications for people as potential flexibility providers in the energy system. Next, I discuss what end-user flexibility could mean, including for what and for whom.

9.3 Just flexibility?

Reducing the peaks in the electricity grid and increasing flexibility can reduce issues with balance and effect, and synchronization, and can improve security of supply, in addition to saving costs by limiting extra infrastructure. It is also considered an important factor in catering for increased electrification, and hence reduction in carbon emissions (e.g. Eyre et al., 2018; Markard, 2018; Öhrlund, 2020). Based on the analysis in the four research papers (Papers 1–4), it is apparent that 'flexible' electricity consumption probably will not entail more flexibility in the daily life of energy users. The results and discussion in this thesis suggest that electricity consumption is intertwined with a myriad of internal, external, social, structural, cultural, and material factors, which exceed individual willingness and abilities to change energy consumption, in line with previous findings (e.g. Adams et al., 2021; Aune, 1998; Aune et al., 2016; Christensen et al., 2017; Ryghaug & Næss, 2012; Shove, 2003; Shove & Cass, 2018; Skjølsvold et al., 2018; Stephenson et al., 2015; Torriti, 2019).

In this thesis I have demonstrated how it is harder for some social groups to reduce or change their electricity consumption during peak hours, and how this is linked to factors such as 'flexibility capital' (Powells & Fell, 2019), which may lead to flexibility poverty. I have also disclosed new types of injustices associated with end-user flexibility. In the following, I briefly summarize some of the findings and then further discuss the concept of end-user flexibility by reflecting on the potential of added labour stemming from pushing for more flexible electricity consumption.

During the research for Paper 3, I and my co-authors found that that even though many students saw the potential to consume electricity more flexibly, their current consumption was to a large extent locked in due to structural, material, and social factors, such as education schedules, housing facilities, and social relations. Thus, the flexibility potential for students collectively was low. The same tendencies were found during the research for Paper 4, when I and my co-author analysed traditional householders use of technologies and activities in terms of their flexibility and rigidity. Most consumption was locked in and linked to daily routines, work, and family life. In Paper 2, four options for 'flexibility work' are identified in terms of which alternatives householders had for consuming less electricity during peak hours: (1) manually reducing or shifting consumption to times outside peak hours (e.g. rescheduling activities or use of technologies to before or after peak hours), (2) use already installed systems (e.g. smart home systems, appliances, or devices), (3) invest in such systems to manage flexibility, or (4) outsource the management of flexibility work (e.g. through aggregators). As discussed in the paper, which alternatives will be available for householders to perform flexibility work is closely linked to how high or low the users' flexibility capital is.

In the context of this thesis, flexibility capital is understood in the sociological sense, as more than just financial capital (e.g. Bourdieu, 1986). Therefore, it can be connected to factors such as knowledge and competency to manage flexibility systems, interest, and surplus time spent becoming familiar with new gadgets or technologies, and capacity to navigate the market for various alternatives, or even creativity. Having low flexibility capital does not in itself necessarily foster problems, as long as financial resources are available to compensate for the lack of flexibility capital, meaning that some households can afford to not be flexible with electricity consumption by accepting increased energy costs. However, low flexibility capital in combination with fewer financial resources can create tension between energy expenses and daily comfort and convenience.

Furthermore, in Paper 3, I and my co-authors suggest that some people may find themselves in a situation of 'flexibility poverty', due to limited capital, capacity, time, and space to act on their flexibility. In such cases, they would have limited alternatives to engage in flexibility work, as well as few resources to cater for increased expenses. We argue that people who are flexibility poor are more exposed to energy poverty, particularly if flexibility becomes a commodity. As suggested in this thesis, those who have low flexibility capital and are more vulnerable to flexibility poverty and energy poverty are typically also in social groups that often fall outside the scopes of energy policies and energy research, such as renters, low-income households, students, and others in vulnerable life and living situations. In this way, some social groups may become even further excluded from participating in low-carbon energy transitions. For example, energy engagement through materiality, such as electric vehicles, smart home technologies, or solar cells, could create energy citizenship among members of the public who are already advantaged, but could lead to the exclusion of those in less advantaged social groups (Ryghaug et al., 2018).

In this thesis, I have used the term end-user flexibility to describe how users of electricity can (or cannot) be flexible in their electricity consumption by shifting or changing consumption to avoid high electricity demand at peak hours. Hence, I have addressed end-user flexibility as a means to achieve a goal, which is to reduce consumption peaks in the electricity grid. In the next subchapter, I discuss how the concept of end-user flexibility may be understood as delegation of labour and responsibility away from the energy system and towards the users.

9.4 Not just flexibility: end-user flexibility as delegation of labour and responsibility

End-user flexibility can be understood as a result of transferring a piece of work from one sphere to another. For instance, it has been noted in sociological studies of the division of labour related to consumption that labour is sometimes delegated away from the producer and towards the user or buyer (e.g. Glucksmann 2016; Wheeler & Glucksmann 2015). Examples of this practice include how some products, such as furniture from IKEA, comes in pieces and the user is delegated the labour of putting the furniture together, and how diners at some restaurants are delegated labour, such as ordering food via an app, collecting food from the kitchen counter, and clearing the table. Thus, parts of the labour and responsibility related to the consumption of goods or services are moved from the paid labour market to the unpaid domain. It is interesting to note that end-user flexibility can also be understood as a delegation of labour and responsibility away from the energy system (e.g. through energy providers, grid companies, policies) and towards the users. By viewing end-user flexibility as a way to delegate work and responsibility away from the energy system and towards the users combined with the notion of 'flexibility work', which is developed in Paper 2, we may broaden our understanding of how labour is related to end-user flexibility.

The four options for flexibility work (listed in the preceding subchapter) involve different types of paid and unpaid labour. The first alternative, *manual flexibility work*, can be characterized as unpaid domestic labour. The efforts to shift or reduce electricity consumption during peak hours are left to the user alone, and they are made by rearranging the timing of activities or use of technologies. The work must be performed by someone – typically a 'flexibility woman' (Johnson, 2020) – who has the overview, knowledge, and competency to organize and delegate domestic chores, while also responding to external signals, such as effect tariffs. The three remaining alternatives in flexibility work – *use already installed systems*, *invest in systems to manage flexibility*, or *outsource the flexibility management to external actors* – all involve an element of outsourcing labour. The outsourcing can be to either technologies already installed or purchased, or to flexibility management services. Thus, the outsourcing of flexibility work re-enters the paid labour market in terms of users buying services or goods that can perform flexibility work for them. As an example, a household may buy services or goods to perform other domestic chores such as cleaning, for example by hiring cleaning assistance or buying a robot vacuum cleaner. However, it is important to note that the three options that involve outsourcing flexibility work will only be available to those who can afford to do so.

In addition, outsourcing of domestic labour does not happen on its own; it needs to be organized and maintained. Some studies suggest that smart home technologies tend to create additional labour for households in terms of overseeing, optimizing, and maintaining the equipment, also termed 'digital housekeeping' (Tolmie et al. 2007), as it comes in addition to other domestic housekeeping chores (Kennedy et al., 2015; Rode & Poole, 2018; Strengers & Nicholls, 2018). As an illustration, in the same way as in ordinary housekeeping, digital housekeeping also requires more additional work: There will always have to be a human to make the appointment with the cleaning assistant and clear up before they come, or to empty the dustbin of the robot vacuum cleaner and make sure the machine does not 'eat' cables or socks while in operation. Thus, it is clear that the technocratic vision that technologies can take over domestic labour from humans, and thus free up time for leisure, is being challenged (Sadowski et al., 2021). Labour related to flexible electricity consumption has many of the same characteristics as other domestic chores, as it demands efforts from the users in terms of planning, overseeing, and performing the manual labour or the outsourcing of labour.

When the responsibility for flexibility is moved from the energy system to users via individualized solutions such as price signals or automatic technologies, the labour and responsibility will be moved from the paid labour market to the unpaid labour market. In some cases, the flexibility work will be partially moved back again to the paid market. This will happen when the work is outsourced from users to technologies or services. However, there is always some element of labour that the users must perform. The choice of who is able to redelegate parts of the flexibility work back to the paid labour market or to flexibility technologies and who are left with the load of manual flexibility work is neither random nor evenly distributed in society. Those who are left with the responsibility and load of unpaid manual flexibility work will most likely be people who are less affluent, such as students, low-income households, the unemployed, pensioners in receipt of minimum pensions, involuntary renters, and people in temporary life and living situations.

To conclude, it is most likely that the implementation of end-user flexibility will add labour to all electricity users and add yet more labour to vulnerable social groups. Thus, the effects of end-user flexibility might paradoxically be less individual flexibility and freedom, in addition to reproducing or creating new injustices. Thus, to mitigate energy injustices while also moving forward with end-user flexibility, we must continue to open 'black boxes' and possibly open for alternative, less individualized, flexibility pathways. Could we take alternative and collective approaches to end-user flexibility, for example by reorganizing some of the societal structures that enforce peaks in electricity consumption, such as organization of work or family life? Some studies show that a reduction in paid working hours has the potential to improve physical and mental health and well-being, reduce overall energy consumption, and mitigate climate change (e.g. Fitzgerald, 2022; Fitzgerald et al., 2018; Gunderson, 2019). Further examination of such alternative paths, seen in combination with end-user flexibility and energy justice, are worth pursing in future research and energy policy.

Furthermore, it is pertinent to ask how much is end-user flexibility worth in our society, and what (and whom) should we be willing to sacrifice in order to obtain it, and what are the alternatives? These are crucial questions to debate before fine-tuning flexibility technologies and implementing incentives for end-user flexibility in the mass market. We need to acknowledge energy justice issues concerning end-user flexibility and the role of users in terms of how we distribute burdens and benefits, address where injustices occur, recognize who is included, excluded, ignored, or misrepresented, and identify who has the power of definition and who are recognized as knowledgeable. We must also address how we value people's time, unpaid labour, and freedom, if we want to achieve flexibility that is just.

10. Conclusions

Two of the seventeen Sustainability Goals formulated by the United Nations are 'Take urgent action to combat climate change and its impacts' and 'Ensure access to affordable, reliable, sustainable and modern energy for all' (United Nations, 2015). These goals emphasize the urgency of reducing carbon emissions to fight climate change, while also ensuring social equity. Replacing fossil fuels with renewables as energy sources is part of the strategies to reduce carbon emissions. However, using electricity grids as infrastructure to transfer increasing amounts of energy from renewable and variable energy sources puts extra strain on grids and gives rise to a series of social and technical challenges.

In this thesis I have used a socio-technical lens to focus on flexible electricity consumption, also termed 'end-user flexibility'. This has been done by analysing expectations with regard to flexibility solutions, and how flexible electricity consumption relates to broader aspects of life, such as norms, materiality, temporal rhythms, organization of society, and energy justice. My aim has been to answer the two research questions: *How is flexible electricity consumption shaped by expectations, energy culture, and everyday practices? What are the energy justice implications of end-user flexibility?*

The thesis outlines a two-sided story about end-user flexibility. On the one side, there is the electricity systems' need for a more predictable and less fluctuating energy demand, in order to cater for increased electrification and low-carbon transitions. This is expressed through system developers' desire to create solutions that encourage end users to consume electricity flexibly. This side of the story primarily emphasizes the technical and economic aspects concerning flexible consumption and the role of people as part of energy systems. On the other side, there are the users of electricity, who consume electricity as a way of performing their daily life routines and activities, which in many ways are linked to the way modern life is lived. This side of end-user flexibility draws attention to the everyday aspects of flexible electricity consumption and the role of people in energy systems. The discrepancy between experts' and users' understanding of end-user flexibility points to an 'epistemic divide' (Maranta et al., 2003), where the world is understood and experienced differently by experts and lay people. Both sides of this epistemic divide have been studied in this thesis by analysing narratives from experts who work to develop energy systems for the future, and users who consume electricity as part of daily life.

A general observation to be made about the epistemic divide is that techno-economic perspectives hold an 'epistemic authority' (Raviv et al., 1993; Traweek, 2021), meaning that insights from these perspectives hold an authority of knowledge that is recognized and respected when it comes to the development of flexibility solutions and energy policies. Currently, smart grid network actors and experts have the power to decide and reinforce which objectives are important for them when it comes to end-user flexibility and the role people will play in future energy systems. Deciding whether the energy systems' demand for flexibility is more important than users' electricity needs in everyday life suggests that there is 'epistemic injustice' (e.g. Kidd et al. 2017; Valkenburg et al. 2020) concerning end-user flexibility, in that some perspectives and actors are recognized as more valuable and knowledgeable compared to others. Paying attention to this epistemic divide and authority may be a way to bridge the divide and mitigate epistemic injustices.

Moreover, this thesis suggests that we must look beyond the purely technical and economic solutions to accommodate a more flexible domestic consumption of electricity, in addition to questioning the fundamental nature of end-user flexibility as an ideal. Flexible electricity consumption demand work and responsibilities that are hard or impossible for some electricity users to take on. Thus, targeting economic rationality will not be sufficient to foster changes in consumption for *all* users. Price is only one of many interrelated factors that motivate users to change energy consumption (e.g. Christensen et al., 2020). More importantly, for users to domesticate end-user flexibility, it must be *practically feasible*, *meaningful*, and *make sense* for them in everyday life. For example, saving electricity costs by washing clothes at night did not seem sensible or meaningful for most participants. However, changing or reducing consumption in solidarity with the local community or for the benefit of the environment was considered meaningful by some participants.

In this thesis, I have criticized the proposed flexibility solutions for being portrayed as fair and neutral, for being excluding in their design, and for being individual-oriented. I have argued that this is problematic when energy justice aspects of end-user flexibility are brought into consideration, as the responsibilities for the energy system's flexibility are shifted towards the users, and there is little consideration for heterogenicity among user groups in terms of capacity to handle flexibility technologies or incentives. To not fully acknowledge the socio-technical nature of energy systems and flexible electricity consumption – and the implications of the solutions intended to promote this – may reinforce existing or creating new injustice. This would not align with the 'leave no one behind' pledge in the 2030 Agenda for Sustainable Development (UN System Chief Executives Board for Coordination, 2017).

In addition to addressing the issues with flexibility solutions and the justice implications of end-user flexibility, this thesis raises fundamental questions that challenge the concept of end-user flexibility as it is current form. This has been done by asking the following questions: What and for whom is end-user flexibility for? What does it mean for users to be flexible in their electricity consumption in use situations? How does end-user flexibility relate to larger societal concerns, such as energy justice? I argue that flexible electricity consumption will, in many cases, mean to adopt a less flexible way of living, particularly for vulnerable and 'untraditional' electricity users. I also argue that end-user flexibility is a way of shifting responsibilities and work from one sphere to another, whereby the workload shifts from a sphere of paid labour to a sphere of unpaid domestic labour. This argument is critical and needs to be highlighted in discussions about future energy systems and flexible electricity consumption.

To summarize, this thesis can be read as a critique of the epistemic authority that techno-economic perspectives hold with regard to end-user flexibility, as these perspectives disregard many of the aspects highlighted by socio-technical perspectives, such as the cultural and social factors that reinforce temporal rhythms and create 'peaks' of electricity consumption, user-technology relations, and energy justice concerns. Consequently, continuing to explore the socio-technical nature and energy justice implications of flexibility innovations and energy policies will be key in the years to come.

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