Everything counts - The good energy citizen and sociotechnical imaginaries in digitalization experiments in Swedish households

Dick Magnusson, Department of Thematic Studies – Technology and Social Change, Linköping University

Harald Rohracher, Department of Thematic Studies – Technology and Social Change, Linköping University

Mohsen Farhangi, Department of Thematic Studies – Technology and Social Change, Linköping University

Draft paper based on the project "Households as infrastructure junctions: energy systems integration at the user level"

Do not cite without permission of authors!

Abstract

The focus of this article is on experiments in digitalization of households in Sweden. The argument is that these experiments reflects a sociotechnical imaginary based on electrification and the promises of digitalization, and how the co-evolution of the two in the end leads to decarbonization of the energy system. In the logic of sociotechnical imaginary lies ideas of the 'good citizen', which resonates with the strand of literature around energy citizenship. We studied four experiments in various places in Sweden, all with a focus on households and testing out how steering of energy usage through smart devices could be beneficial for the overall performance of the energy systems. We have interviewed 27 persons in total, with project managers in all experiments and several households in all experiments.

Our conclusion is that the project managers had a rather aligned view of the future development of the energy market, in terms of there being practical issues to handle in terms of grid capacity limitations, and how digitalization could help this. In the sociotechnical imaginary, was a clear idea of a continued electrification of the Swedish society, and that the capacity problems will increase. In order to manage the problems, households need to be reconfigured to active nodes that can be steered for load shifting. However, for this to happen, households needs to be enrolled, and in the projects the households were sold on ideas of economic savings, better comfort, and environmental gains, as well as 'helping the system', playing towards an understanding of energy citizenship. The logic and the experiments raises questions of who helps who, what are the responsibilities of each part, where does the willingness to be good citizens end, as well as trust and issues of transparency when new actors, in this case companies offering digital solutions for the households, enter the energy sector and gains responsibility.

1. Introduction

In recent years, a few trends have been evident in the energy systems in western countries: decarbonization, digitalization, and electrification. Often these trends are bundled together, and how they can co-evolve in order to speed up the energy transition. By electrifying industrial processes, transportation and household activities, the goals of climate neutrality are considered to be within reach (Nadel, 2019; Son, Kim, & Kim, 2022; Sovacool et al., 2020).

Much effort and subsidies have been invested in projects and programs that tie decarbonization, digitalization, and electrification together in Sweden. Programs have focused on supporting households and industries investing in solar PV, electric cars, energy storage but also on various aspects of experimentation around smart grid (Envall, 2021) and flexibility markets (Fjellså, Silvast, & Skjølsvold, 2021; Grunewald & Diakonova, 2018). Government policies have been clear on the ambitions, especially in the electrification strategy, as reflected in the quote below :

> *The aim of the electrification strategy is to lay the foundation for widespread electrification that contributes to attaining the climate goals. At the same time, Sweden must have a robust electricity system with high security of supply, low environmental impact and competitively priced electricity. (Government Offices of Sweden, 2022, p. 5)*

In this paper we argue that the electrification, and the co-evolution of the three trends, can be considered a sociotechnical imaginary. The theoretical concept has evolved and is commonly defined as 'collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology (Jasanoff & Kim, 2015, p. 4)

In line with the findings of Ballo (2015), we argue that there is a gap between how various aspects of smart grid development is being communicated to the public and the experts´ imaginaries of the future smart grid. The focus of this paper is on the customer, and household level, in order to understand how these trends affect them. We see a tension between on the one hand, how the imaginary mirror views of energy citizenship (Devine-Wright, 2004, 2012; Ryghaug, Skjølsvold, & Heidenreich, 2018), where the customers both actively and passively use the new technologies and smart technologies in order to help the transition, but on the other hand, another layer of complexity is added to the already complicated energy system. The liberalization of the energy systems is another factor that arguably has become stabilized, at least in terms of acceptance, but with the digitalization, new private actors enter the energy sector. How can customers be expected to fully understand the system, their role and how their energy usage affects the energy system? In addition, the recent events after Russia's invasion of Ukraine, have led to an international energy crisis, and in Sweden, the electrification and decommission of old nuclear power plants, and increased share of intermittent energy sources, have led to fluctuating energy prices, that are higher than ever before. The customers are thus more vulnerable than during previous decades, and then promises of digitalization may seem promising.

The aim of this paper is to analyze pilot projects focusing on digitalization of energy system, in order to understand the role of the households and how ideas of energy citizenship and sociotechnical imaginaries are aligned.

The paper is structured as follows: first a description of the methods used, and the cases studied, then the theoretical points of view are presented, followed by the results, and finally a concluding discussion.

2. Methods

The focus in the paper is on the users in the energy system, starting out from their roles and experiences in different pilot projects, focusing on various forms of digitalization and reconfiguration of the energy systems. In total, four different Swedish pilot projects were studied: Thermo-S in Åre in Northern Sweden, Växel and Klokel outside of Uppsala, and Simris in Southern Sweden. The cases will be described in section 2.1.

The cases were selected based on a mapping of pilot projects in Sweden focusing on digitalization, user integration, and energy system optimization. All of them focused on digitalization of the energy system, with a specific attention on households.

A total of 27 interviews were conducted (seven in Åre – six with households and one with the project managers, eight in Klokel – all of them households, eight in Växel – six household and two project managers that described both Klokel and Växel, and six in Simris – three households and three project managers) between 2020 and 2022. It should be noted that all interviews, except with the households in Simris, were carried out in before December 2021, which arguable was the point in time when the trend with stable and low electricity was broken (von Platten, 2022). Due to the covid-19 pandemic, all interviews in Åre and KlokEl, as well as with project managers in Simris, were conducted via telephone or via MS Teams, and the rest of the interviews were conducted in person.

The interviews with the households focused on their involvement in the pilot project, how they understood the goals of the pilot project and which information they had received regarding joining the project and regarding installation of components, if they had changed their behavior, or if their understanding of their role in the energy system had been affected. The focus of the interviews with the project managers focused on the overall aim of the pilot projects, the communication with the users, results of the project, and future development for the energy systems.

The interviews took between 30 minutes and 2 hours, and in three cases more than one person from the households attended the interviews. The interviews were transcribed and later coded and analyzed based on thematic analysis.

In addition, relevant documents around the projects (mainly information and marketing material) as well as eventual academic publications, were read in order to contextualize the projects and to inform the construction of our interview guide.

2.1 Case description

In the next section the studied cases will be presented.

2.1.1 Thermo-S

The Thermo-S-project in Åre was run by the municipal energy company Jämtkraft between 2018 and 2021. It focused on the district heating (DH) system, a heating system widespread in Nordic countries with production of heat in a large heating plant and transportation of hot water in pipe systems underground to connected houses and non-residential premises. On a national level, DH makes out more than 55 % of the total heating market and in certain municipalities the market rate is considerably higher. In the pilot project, the aim was to reduce heat demand during peak hours, via remote control of the heating systems in the homes, via 'smart thermostats' provided by manufacturer Ngenic. Jämtkraft could via the thermostats increase the heat before the peak hours, when demand was lower, and then reduce the heating in the houses during peak hours, and making use of the built up heat in the building and using the houses as accumulators within the system. The customers would get the thermostat for free if they joined the pilot, and it was marketed to customers through both reduced costs and better indoor comfort with more even temperatures, as well as an opportunity to "help the grid" by reducing heat during peak hours (cf. Velkova, Magnusson, & Rohracher, 2022).

2.1.2 Växel and Klokel

Växel and Klokel have several similarities. The three main actors have been DSO Upplands Energi (UE), Ngenic, and the organization Sustainable Innovation (SI) (which is owned by members and work with various kinds of projects with focus on innovation and up-scaling). The main focus in KlokEl was to via a pilot project try to gain a controllable electric capacity (flexibility) of 1 MW based on 500 customers. One of the main logics was that UE had problems with capacity limitations at peak hours, and through this project, they could avoid using too much electricity capacity at peak hours (which costs money). The customers were all connected to UEs electricity grid, were mainly detached houses, and with electric heat pumps. By installing the smart thermostat from Ngenic, UE and SI could steer to usage of the heat pump, in order to shift the electricity load in the households and avoid peak hours. In total, 377 customers were part of the pilot, running from 2014 to 2018. In VäxEl, focus was on fewer households that has solar PVs, batteries, heat pumps, and in some cases EV chargers. The goal was to understand how the electricity grid can be run with all these new components, and to analyze how steering of components can help the system at certain times.

2.1.3 Simris

Simris is a small village in southern Sweden, with mainly single houses. The grid owner is E.ON, who initiated the project, focusing on creating a microgrid that could be run in island mode (i.e. being disconnected from the grid). There were already wind power plants and a solar PV park in the outskirt of the village, and by adding a battery capacity, a backup generator, and a control system and steering devices in the households, the potential to technically run the microgrid in island mode was possible. There are 150 households, and all were asked to participate in the project by adding the steering devices to their heat pumps. Through the steering devices, the heat pumps, and in some cases batteries, could be steered by E.ON in order to create a virtual battery, and thus flexibility in the local grid (Warneryd & Karltorp, 2022).

3. Theoretical framework

In the paper we take departure from two strands of literature: sociotechnical imaginaries and energy citizenship. We see how the two theories can complement each other in the analysis, as the digitalization of the energy system in many projects and policy initiatives tend to emphasis flexibility and demand management and the role users and households play in the development.

3.1 Sociotechnical imaginaries

The concept of sociotechnical imaginaries was introduced by Jasanoff and Kim (2009), focusing on nuclear power development in the US and South Korea. They define it as 'collectively imagined forms of social life and social order reflected in the design and fulfillment of nation-specific scientific and/or technological projects.' (Jasanoff & Kim, 2009, p. 120). The starting point is out of nations long-lasting policies for science and technology, and how ideas of the future shape the decisions around investments. The imaginaries describe attainable futures and also prescribe futures that are desirable in the mind of state policy makers, and how 'the capacity to imagine futures is a crucial constitutive element in social and political life' (Jasanoff & Kim, 2009, p. 122). They further argue that imaginaries are not the same as political agendas, as they are less explicit, less instrumental and less politically accountable, but they reside around existing norms and discourses, metaphors and cultural meanings which influence various actors' policy preferences.

In 2015, they elaborate on the concept, in order to go broader than 'only' power dynamics, and to stress the aspect of the sociotechnical, and how the interplay between technology and society matters in the analysis: 'Unlike mere ideas and fashions, sociotechnical imaginaries are collective, durable, capable of being performer; yet they are also temporally situated and culturally particular. Moreover, as captured by the adjective "sociotechnical", these imaginaries are at once products of and instruments of the co-production of science, technology, and society in modernity' (Jasanoff & Kim, 2015, p. 19).

Jasanoff and Kim (2009) start out from the perspective of nations sociotechnical imaginaries, but later studies have expanded on this and analyzed other geographical scales and organizational settings (Jasanoff & Kim, 2015), and as Sismondo (2020) argues, the imaginaries are often contested, changeable, and flexible. They should thus not be seen as a strict rules on how policy should be expressed or implemented, rather as something that can help explain paths taken, or as Rudek (2021p. 219) expresses it: '[sociotechnical imaginaries] affect the allocation of funds, research directions, means of communicating development priorities'.

Sociotechnical imaginaries has emerged as an important concept within energy research, and Rudek (2021) identified that the number of relevant articles has increased steadily since 2009. Many of the studies have focused on smart grid development, something that is in line with focus on policy of decarbonization, and how new technologies, via digitalization, can help reshaping the energy system.

Ballo (2015) shows how the installation of smart meters in Norway is surrounded by sociotechnical imaginaries from the industry actors. The ideas were connected to views of how customers were to act and be influenced by the new technology, and

especially how the communication to the public was simplified in order to only stress the advantages for individual consumers, while the goals and imaginaries of the development from the industry actors rather focused on saw smart meters and smart grids as solutions to challenges in the energy supply grid. Ballo (2015) further showed that a main point of the installation of smart grids was the possibility to remote steer the customers, in by doing that "helping the system" with load shifting, but without actual active engagement from customers.

More specifically, and of importance for this paper, there are a few studies in Sweden, focusing on sociotechnical imaginaries. Christiansen and Carton (2021) focused on the aspects of conflicting and ambiguous sociotechnical imaginaries in negative emissions technologies in Sweden. They argue that the aspect that it is an emerging sociotechnical imaginary adds to the contestation and show how different actors mobilize towards different imaginaries, for example in the aspect of how bioenergy with carbon capture and storage (BECCS), how the technology ties well in with already established institutional and political-economic interests.

Mutter and Rohracher (2022) analyzed the development of competing imaginaries in the Swedish transport sector. On the one hand, the role biogas can play and on the other electrical vehicles. They show how the latter to large extent is supported by national and international imaginaries of electrification more generally, and how electrification of the transport sector is a logical step in this development, as electrification plays a crucial role in national policy in fossil free energy development, no matter the role of nuclear power. Identified controversies focus for example on grid capacity limitations, which is a main focus in smart grid development, and the aim to reduce the impact of these.

3.2 Energy citizenship

The concept of energy citizen was introduced by Devine-Wright (2004) and have been used and further developed in several publications since then. Devine-Wright (2012) argues that, based on Aronson and Stern (1984), energy can be represented in four ways: as a commodity, as an ecological resource, as a social necessity, and as a strategic material. Based on a perspective with energy seen as a social necessity, a specific set of prerequisites appear, and especially around how energy meets essential needs and how the availability matter. Devine-Wright (2012) thus see the emergence of sustainable development as a policy goal as a new component of energy as a social necessity, and how ideas around energy citizenship emerge. He argues that it calls for "social necessity of public engagement and participation in processes of policy-making and planning, driven by principles of local empowerment and action derived from Local Agenda 21" (Devine-Wright, 2012, p. 67-68). It means different assumptions about public awareness, motivation and concern on energy, and thus the public are seen as active stakeholders in energy system evolution. They can thus be democratically engaged in sustainable energy transitions, and how the concept highlights energy consciousness and literacy, and also sustainable energy practices.

An important aspect is that of community, as the concept puts an emphasis on moving from centralized, fossil-dependent energy systems to renewable and decentralized system approaches (Devine-Wright, 2012; Ryghaug et al., 2018). The relationship with concepts of energy community (Kooij et al., 2018; Seyfang, Park, &

Smith, 2013; Smith, Hargreaves, Hielscher, Martiskainen, & Seyfang, 2016) is important, and how interactions between people and coming together makes certain developments possible, for example in joint investments in renewable energy, but as argued by Ryghaug et al. (2018), engagement can also be as individuals through energy efficiency measures in households or investments in renewable energy technology.

In relation to the energy citizenship concept, Ryghaug et al. (2018) have analyzed the new ways citizen engage with renewable energy technologies, and what it means for sustainable transitions and the role as energy citizens. They focus on what they call mundane practices, in the sense that an increasing number of people will invest in renewable energy production, for example in solar PVs, automation, batteries, and feedback technologies, and that energy production will become a mundane practice, as the interaction with the technology will be routinized. They further connect the concept with 'material participation' (Marres, 2012, 2013) and identify three processual qualities from their analysis: material localization, integration, and diversification.

For our study the aspect of integration is important, and how they identify that how renewable energy technologies becomes integrated with each other, for example in how solar PVs and electric vehicles "links practices of mobility to practices of electricity use and electricity generation, all within the localized space of a household, neighborhood, or city (Ryghaug et al., 2018, p. 48).

An important aspect of the energy transition is that of integration of digital technologies that gives opportunities to control and steer usage in new ways. Devine-Wright (2012p. 77) argues that:

> *energy citizens can feel positive and excited about new energy technologies rather than apathetic and disinterested; be aware rather than ignorant of the scale of its potential impacts on political institutions, the environment and everyday lifestyles; and be willing to engage not just as individuals but as collectives in shaping technological change at local, regional and national levels.*

This can mean that individuals are capable and motivated to engage with the wider energy system via new energy technologies such as 'smartmeters' (Devine-Wright, 2012). On the other hand, Lennon et al. (2020) argue that policy in the EU have moved towards a normative understanding of users as 'good citizens', but based on market-driven components, shaped by incumbent energy market actors. The structure of the energy systems, being still a strong market-oriented, neoliberal logic are rather shaped in ways that give very little agency to the majority of the citizens. At the same time, in the argument of Lennon et al. (2020), responsibility tends still to be shifted from the state back to the citizen consumers, as they are often stated to install energy efficiency measures in the household, as ways to help the system and contribute to the transition. Often, the emphasis in the communication towards citizens are that they can save money, increase comfort, and prevent climate change, and this communication is often framed around taking individual responsibility to contribute to sustainability. Lennon et al. (2020, p. 189-190) further argue that:

> *Citizens are repeatedly (re)imagined as economic actors whose participation in the energy transition is based on their role as consumers, making individual choices in the privacy of their own homes. They are also assumed as having the financial, property, educational, organisational and time resources to reflect on and exert meaningful control over their energy usage. Consequently, the normative model of the 'good citizen' implicit in this initiative is one which reinforces the market-driven paradigm of the current energy system, as well as the central regulatory role of the state.*

For the purpose of the analysis in this paper, we draw on ideas from energy citizenship, but mainly on the role they play as individuals, and not in the sense of active members of energy communities.

4. Results

In this section we will present the results from the case studies. We start out with the perspective of the project managers and energy companies, in order to understand their sociotechnical imaginary and how ideas of energy citizenship ties into this, and then we present the results from the interviews with households.

4.1 The perspective of the project managers

This section is structured around aspects of driving forces and imaginaries, customer relations, and project logics and learning.

There are differences between the projects, for example in terms of technologies implemented in the households, ownership, and energy system configurations, but several similarities. One striking similarity has to do with identified present, and increasing, concerns about future grid capacity, and to start innovating to utilize the opportunities that the digitalization brings. In this aspect, there is no difference between Åre, with DH, and the other projects which are mainly focusing on electricity, as the ambition is peak shaving by moving demand a few hours forward or backward. The motivation in Åre has to do with limitations in capacity in the production plant, transmission, and high investment costs to handle this:

> *Respondent 1: And then there have been discussions about building a small accumulator, which takes these morning loads. A small accumulator of, as you see, 100 to 500 cubic meters. To even out.*
>
> *Respondent 2: But it is still an investment of four to six million [SEK]. But compared to the digitization of the grid, which costs less than that, and utilizes ... So, digitally, we utilize the grid as an accumulator and the buildings. And that's where, so to speak, digitization comes in for us. We can therefore smooth out these morning peaks and evening peaks. And an accumulator can do that too. But the disadvantage of the accumulator is that it is located at one point. So local transfer restrictions for example, you can't handle that. (Representatives Thermo-S-project).*

The same challenge is evident in Björklinge, were KlokEl and VäxEl were located, relating to limitations in electricity grid capacity, and the high costs in buying

capacity reserve during peak hours. By being able to steer heat pumps in households, it is possible to load shift during peak hours to avoid high costs.

In these projects, especially in VäxEl and in Simris, the future vision also focused on the assumptions of increased amounts of renewable, decentralized energy production in the grid, together with storage capacity in batteries, and increased amounts of electric vehicles, due to electrification processes in general in Sweden. For the VäxEl-project, the ambitions were to expand into understanding which challenges these new system configurations would put on the system, and Similar ideas were true in Simris, in relation to understand the development of micro grids.

> *And we discovered or found out that micro grids were something several actors were talking about and nobody actually, at that time, knew what it actually was. So, we decided that it's something that could affect our business and our grid companies all over Europe. So we thought that we had to learn a little bit more about that (…) So we wanted to test different customer, how do you say, customer situations. There are customers with solar panels and batteries in their houses, old traditional heat pumps, and also new heat pumps, because that is a different controlling equipment. And also if they only had heat water and boilers. And to have that into the same system to balance the energy system (Project manager, Simris).*

Put together, the main driving forces was to manage capacity limitations in grids, which affected the economic results, together with the ongoing development towards higher degrees of renewable and decentralized electricity production, along with an increased amount of system components, in the system. Seen through a lens of a sociotechnical imaginary, this is in line with electrification strategies in general, and higher degrees of renewable energy, and one of the key solutions, and an increasingly important factor, is the digitalization. Christiansen and Carton (2021) and Mutter and Rohracher (2022) have described how actors can work in parallel with competing imaginaries, but in the project and in the overall visions of these companies, the imaginaries are aligned and surrounded by consensus. Electrification has gained enough momentum, and digitalization already has entered the energy system, so now it is rather the time to follow the development, but also to try to be a part of steering the development. By implementing these research projects, which are framed much like technical projects, they can learn and be prepared to compete in the future markets. It should be noted that all the projects had received substantial funds for research, through external state funders, which adds to the aspects of learning and of trying to understand the future paths.

Arguably, in the envisioned sociotechnical imaginary, the customers are more active nodes thanks to digitalization and an increased number of technical components that are affecting the energy system in more substantial ways than earlier. Thermo-S is the outlier, due to the focus on DH, but the technology for steering the demand in the households are the same as in the other projects, meaning that knowledge from the experiment still can be relevant. Being able to manage the households as controllable nodes means that new components needs to be added, and in this case steering devices, and that needs to be done with the permission of the customers, and thus in

cooperation with them. The development of increased amounts of e.g. solar PVs and EVs will continues regardless, and thus enrollment becomes the solution.

> *Yes, we are trying to work with an image with the smart house, so to speak. Where you have solar cells, you have a battery plant, you have a rechargeable car and you have a type of heat pump plant. And these must work as well as possible, both for the benefit of the customer, and contribute to the benefit of the network, and contribute to the environment, of course. (Project manager, UE)*

The energy companies have used different strategies to enroll the households in the projects. In all of the cases, the controllable devices that are necessary for remote steering by the energy companies have been either given for free, like smart thermostats from Ngenic that can control the heat pumps, or substantially subsidized, like batteries in VäxEl or in Simris.

> *And a lot of them were like 'We would like to participate in this project because of environmental reasons' but in practice what really motivated them was the financial incentives. So, for the new heat pumps and for the new solar systems we offered them a 50% discount on these devices. So in some cases we paid up to a 100.000 Swedish kronor in discounts. (Project manager, Simris).*

It might seem like a cynical quote, but it reflects very much the discourse around the projects, even among the customers, which we show later. The energy companies frame it around environmental concerns to the customers, and also that they can save money without losing comfort.

It is much in line with the argument of Lennon et al. (2020), in how customers are framed as 'good citizens', in the way that they are helping the system, and at the same time saving the environment and saving money. That is the way the project was presented and market towards the households in Thermo-S, but with a strong emphasis on citizenship:

> *And here you have to remember, if the customer is going to think this is good, then the customer has to get something out of this too. But here I want to be a bit like JF Kennedy. Don't ask what the energy companies can do for you, ask what you can do for the energy companies. (...) We try to make energy customers good energy system citizens. They didn't know how to do it, and they don't know that today either. But digitalization makes customer facilities good energy system citizens, i.e. contribute what they can, but get what they need from society, from the energy system. (Project manager, Thermo S).*

The aims of the project showed some differences in terms of ambitions concerning increasing the knowledge and by extension behavior in the households. In Simris, it was clearly stated that it was seen as a technical project and not to motivate households for further investments or changed behavior. In Åre and Björklinge, the challenges for the energy systems were usually presented to the customers, as part of the marketing while enrolling users in the projects.

A final aspect that was central concerned trust. The municipally or member owned companies of Jämtkraft and Upplands Energi expressed close connection to the customers. This is a crucial factor, as liberalization processes have led to some issues of mistrust with private actors in the energy market, especially in the DH market (Magnusson, 2016). An important aspect is that in all the projects, new actors enter and play a roll through there competence in digitalization. They do also have an impact on the development, and are thus part of shaping the sociotechnical imaginary. Ngenic is one example, who adds a layer of digitalization and remote controlling, and are active in presenting how they can help the energy companies, and the energy companies in our projects are both positive, but also admitting that digitalization is a task that is difficult to keep up with, also in order to be competitive on the heating market in general:

> *A background too, one might say, regarding the product district heating. I think that the industry has failed to, so to speak, find a common way to, above all for residential customers, have a modern product that competes with heat pumps on control, on interactivity, on statistics in the mobile phone. So that's why we want to make district heating a bit modern too. And it has been received positively, above all in Åre, where you have customers who may not be there every day of the week, but want to keep track of the temperature and be able to control it in their house.*
>
> *(…)*
>
> *when you work with digitization and work out in the customer facilities, then you control, so to speak, out in the nodes. And controlling out in the nodes gives an extremely much higher cost efficiency, because then you can do much more with existing infrastructure without risking local limitations as well as global limitations in the system.*

By adding the competence from the companies offering services and devices for digitalization, it is a possibility to gain competence and become competitive, but it is clear that it adds complexity to an already technical and non-transparent system.

In the next section, we will analyze how the customers are reasoning about the projects and their roles.

4.2 The perspective of the households

From the household's perspective, the motivation to be part of the projects are in line with how the project managers were presenting it them. Motives of hopes for economic gains, better comfort, environmental concerns, and to help the system are raised.

> *I like Tesla and I like things that are innovative. Going back to the starting point "how can we act as effectively as possible?" Instead of going around like we do today, maybe we can go a shorter way and like this. I like it. So then I started with solar cells. I knew it might not be the best deal in the world, but I thought I slept well on the first day. (VäxEl3)*
>
> *Yes, I know the benefit for the electricity company. And if I don't notice any difference in comfort, I think … then it's obvious to join. (Klokel3)*

These are strong arguments, and giving the extra carrot to be a good citizen seems important to some of the households. In the interviews, we were in several cases asked if they understood the technical setup correct, that the they are helping the energy system by allowing the energy company to control them for limited time periods. When being confirmed that was the case, it was seen as a positive thing. However, one has to remember that the projects are pilots and that all households in one way or another had been subsidies to join, and when being asked if they were willing to pay for the products, there were more differences in the answers.

> *Because then I'd like to know exactly how much I've saved by doing this, because if I haven't saved so much that it's worth the subscription cost, then I don't know if I'd keep it. (Themo-S 1)*

> *Depends on what kind of money it is [the cost for the service – authors note]. But when I agreed to it, I thought "I wonder if I'm being tricked into something now". I know I thought that. But the benefit I've seen with it makes me... Yes, I'm probably willing to pay a certain amount if that were to be the case. (Klokel5)*

The question is then what they would pay for. Is it only to have smart thermostats and being able to control and save money, or to continue being controlled at certain times. A few of the interviews discussed this from a critical perspective, understanding that flexibility in the energy systems actually is a growing market, and by allowing the house or system components to be controlled, there were critical thoughts.

> *INTERVIEWER: Let's say you bought a battery, you weren't part of VäxEl, what would be required for you to agree to let the battery be controlled?*

> *RESPONDENT 2: No, you have to calculate some kind of wear and tear cost. You must feel that you are getting paid for what you invest.*

> *RESPONDENT 1: A battery, there you have a lifetime with charging and discharging, it can withstand this many charging and discharging. And if you take it out in the end, you need to buy a new battery because it can't last anymore. So that it is a compensation in relation to how much outsiders use the battery. (VäxEl 2)*

This answer was more representative of the VäxEl-households, as they had more system components and were thinking about the usage. When talking to the households in Thermo-S and KlokEl, the picture was a bit different, as the knowledge of the system was not at the same level as in VäxEl. In a few cases, they were not sure what was actually controlled, and many had a rather passive approach, that they felt that the energy company can control what they want as long as the comfort remains the same.

This raises some questions on the sense of being controlled, and the consensus was that most of them never even experienced that their heating system were being controlled, either in the heating systems or when Simris were run on island mode. The exception were the households in VäxEl, that had a more direct contact with their

batteries, and could see when they had been emptied or filled, and some discussed their thoughts around it, but not from a critical perspective as they were aware of that it would be the case. What most of the experienced was rather a sense of increased control, as the Ngenic thermostat was connected to an app, in which the households could set the desired temperature and plan the temperature days in advance. In Thermo-S, in Åre, it was an advantage to be able to control the temperature from afar during the winter when not being there.

It is a bit of a contradiction, that they were all giving away the control over their heating system but felt increased control due to the app. Giving away the control is connected to a trust in the energy company, especially in the ones owned by members and the municipality. The interviewed households get a sense that they are locally connected and that that they do something in return.

> *Interviewer: We have actually been into this regarding Jämtkraft and Ngenic and that you were satisfied with them, but do you have confidence in them as actors in relation to the management up there?*
>
> *RESPONDENT: Yes, I have, I still think it's a for-profit company but reinvesting in a renewable energy and running it, so I think they're doing good things. At the same time, I pay for them to be able to do it. Their business idea is for me to trick them into doing all this stuff, which they also make a pretty good profit on the projects they do. (Thermo-S 3)*

The matter of control and trust becomes an issue as that the households in spite of a sense of increased control were also giving away control of their data. The energy companies reasoned about the importance of data and understanding how to utilize the data in their system management, but what it means for the customers were seldom in the minds of the households. They had the opportunity to read about data management in the agreements, but few knew the content, and it is once again connected to a trust in the energy company. Without that trust, the household would probably not sign up to get involved in the pilot projects and give away control and data, and that trust needs to be handled with care.

> *As long as they take energy statistics from me, I can offer that. It doesn't feel like any danger. But I don't know if they do anything else, those little boxes, and I haven't reflected on that but I don't think they do. But if that were the case, then I would be annoyed. (Themo-S 1).*

Another important aspect has to do with the steering, and who would gain from it. It was evident in these pilot projects that the purpose from the energy companies were to learn about new system configurations and utilize the opportunities given by digitalization, and thus the main aim was to help the system. The customers were on board with the premise, but what became clear is that the control of the system might lead to sub-optimizations for the customer. Demand peaks may arise differently in different parts of a regional grid, and the need to steer might then be at different times in the system, something that came up in the later project Coordinet.

> *We have installed KlokEl so that we can manage for this company. But then it became interesting now, because we had control here, and so we*

are in CoordiNet to contribute to the system even higher then. Then you can see conflict… There can be some conflict here. If we want to drive at seven, but they want to drive at eight… (Project manager 1, UE)

The representative stressed that it became an important discussion and something to learn from, but in a real-life situation, these questions may come up on a regular basis, and decisions need to be made around prioritization and about who should help whom.

Another aspect of the suboptimization has to do with when to use the electricity from the batteries and risks of disadvantages for the customer.

But this means that we take the customer's cheap electricity from the night, send it out onto the network, although probably during an expensive period, but we drain his battery completely. So we wear a bit on the battery. We work against the net. Towards the afternoon, when the customer has accumulated some solar energy, we empty it at five o'clock, out with everything online, switch off the car charger, use the customer to the maximum. And then it can be a little negative for the customer in the economy, but it will be a very good benefit. And (Project manager 2, VäxEl)

Once again questions arise about the actual role of the customer and who will gain the most from the digitalization and the steering of the system. The main winner seems to remain the energy companies, thanks to the customers being willing to be good energy citizens.

5. Concluding discussion

In this article we have analyzed analyze pilot projects focusing on digitalization of energy system, in order to understand the role of the households and how ideas of energy citizenship and sociotechnical imaginaries are aligned.

The results show that ideas of good energy citizen to a large extent is connected to an overall sociotechnical imaginary of how electrification is the most important aspect, but that it is managed through digitalization. In order to digitalize, the role of customers and households are being reimagined, as the households needs to become active nodes in a decentralized energy system. It is very much a matter of solving an urgent problem of capacity limitations in the grids connected to this, and the ideas is that digitalization can be more cost effective. In order to manage this new system configuration, the households need to become more active nodes, and the projects showed the importance of getting them onboard.

One has to remember that the studied projects are pilots, with aims of learning and further development, and that the customers were mainly satisfied with the exception on how the projects were handled after they were finished with a lack of information and some uncertainties regarding the smart meters. However, the results show some questions that needs to be further studied before a larger roll out can be carried out.

One of the questions becomes clear through the analytical lenses of the sociotechnical imaginary that underlies the project and the role of the citizen, or more specifically the vision of the 'good citizen' and energy citizenship. The problems with the systems are practical, due to under dimensioned grids in an increasing demand due to electrification. A rational logic is to invest as cost efficiently as possible, and the digitalization is a promising solution that is cheaper than investing in the grid. One way of doing this is to add a layer of digital components in the households, but that cannot be done at this stage without the permission of the customers. In order to do it, a convincing offer needs to be made, based on economic gains, better or equal comfort, environmental gains, but also to help the system. That is transparent in many ways, but also simplified. The customers are still paying customers, that have paid high prices for grid usage over a long time, so putting aspects of responsibility on the customers is not unproblematic.

The customers express that they need to feel that they are getting something back from their efforts, which is necessary and an important argument. This would be either through economic gains or reinvestments in e.g. renewable production. It also comes down to trust in the energy companies, which most of the interviewed household have. Transparency in what control might mean and what will happen to all data is a crucial factor for the future in remaining trustworthy.

A twist to this development is the fact that electricity usage has gone down in 2021 and 2022, even after temperature adjustments, and conclusion are that changed behavior due to higher prices is a factor (Svenska kraftnät, 2023; Swedish Energy Agency, 2023). The Swedish energy agency have launched a campaign in order to inform and encourage reduced energy usage, in a campaign called 'Varje kilowattime (kWh) räknas' (Every kWh counts) (Swedish Energy Agency, 2022) and newspapers and politicians have stressed the strained electricity situation. It is an significant

development, showing that the main aspect is, not surprising, that cost is the most important factor for most households, and somewhat ironic that 'old school' strategies of information and price signals have a strong impact, but obviously it has to do with direct effects on the households economies. The question is then, what role does these complex projects have? It does not mean that they will not play role for future understanding, the very aspects of understanding the needs of households and how complexity matters, is crucial.

References

Aronson, E., & Stern, P. C. (1984). *Energy use : the human dimension*. New York: W. H. Freeman and company.

Ballo, I. F. (2015). Imagining energy futures: Sociotechnical imaginaries of the future Smart Grid in Norway. *Energy Research & Social Science, 9*, 9-20. doi:https://doi.org/10.1016/j.erss.2015.08.015

Christiansen, K. L., & Carton, W. (2021). What 'climate positive future'? Emerging sociotechnical imaginaries of negative emissions in Sweden. *Energy Research & Social Science, 76*, 102086. doi:https://doi.org/10.1016/j.erss.2021.102086

Devine-Wright, P. (2004). *Towards zero-carbon: Citizenship, responsibility and the public acceptability of sustainable energy technologies*. Paper presented at the Solar Energy Society, London.

Devine-Wright, P. (2012). Energy citizenship: psychological aspects of evolution in sustainable energy technologies. In J. Murphy (Ed.), *Governing Technology for Sustainability* (pp. 74-97). London: Routledge.

Envall, F. (2021). *Experimenting for change? : the politics of accomplishing environmental governance through smart energy pilot projects*. Linköping: Linköping University, Department of Thematic Studies.

Fjellså, I. F., Silvast, A., & Skjølsvold, T. M. (2021). Justice aspects of flexible household electricity consumption in future smart energy systems. *Environmental Innovation and Societal Transitions, 38*, 98-109. doi:https://doi.org/10.1016/j.eist.2020.11.002

Government Offices of Sweden. (2022). *National Electrification Strategy – a secure, competitive and sustainable electricity supply for a historic climate transition. A summary*. (I2022.04). Retrieved from https://www.regeringen.se/contentassets/fe23dccdb7384109a5e39de2c8105432/popversion-elstrategi_eng/

Grunewald, P., & Diakonova, M. (2018). Flexibility, dynamism and diversity in energy supply and demand: A critical review. *Energy Research & Social Science, 38*, 58-66. doi:https://doi.org/10.1016/j.erss.2018.01.014

Jasanoff, S., & Kim, S.-H. (2009). Containing the Atom: Sociotechnical Imaginaries and Nuclear Power in the United States and South Korea. *Minerva, 47*(2), 119-146. doi:10.1007/s11024-009-9124-4

Jasanoff, S., & Kim, S.-H. (2015). *Dreamscapes of modernity : sociotechnical imaginaries and the fabrication of power*. Chicago ;: The University of Chicago Press.

Kooij, H. J., Oteman, M., Veenman, S., Sperling, K., Magnusson, D., Palm, J., & Hvelplund, F. (2018). Between grassroots and treetops: Community power and institutional dependence in the renewable energy sector in Denmark, Sweden and the Netherlands. *Energy Research & Social Science, 37*, 52-64. doi:10.1016/j.erss.2017.09.019

Lennon, B., Dunphy, N., Gaffney, C., Revez, A., Mullally, G., & O'Connor, P. (2020). Citizen or consumer? Reconsidering energy citizenship. *Journal of Environmental Policy & Planning, 22*(2), 184-197. doi:10.1080/1523908X.2019.1680277

Magnusson, D. (2016). Who brings the heat? – From municipal to diversified ownership in the Swedish district heating market post-liberalization. *Energy Research & Social Science, 22*(Supplement C), 198-209. doi:https://doi.org/10.1016/j.erss.2016.10.004

Marres, N. (2012). *Material participation : technology, the environment and everyday publics*. Basingstoke: Palgrave Macmillan.

Marres, N. (2013). Why political ontology must be experimentalized: On eco-show homes as devices of participation. *Social Studies of Science, 43*(3), 417-443. doi:10.1177/0306312712475255

Mutter, A., & Rohracher, H. (2022). Competing Transport Futures: Tensions between Imaginaries of Electrification and Biogas Fuel in Sweden. *Science, technology, & human values, 47*(1), 85-111. doi:10.1177/0162243921996052

Nadel, S. (2019). Electrification in the Transportation, Buildings, and Industrial Sectors: a Review of Opportunities, Barriers, and Policies. *Current Sustainable/Renewable Energy Reports, 6*(4), 158-168. doi:10.1007/s40518-019-00138-z

Rudek, T. J. (2021). Capturing the invisible. Sociotechnical imaginaries of energy. The critical overview. *Science and Public Policy, 49*(2), 219-245. doi:10.1093/scipol/scab076

Ryghaug, M., Skjølsvold, T. M., & Heidenreich, S. (2018). Creating energy citizenship through material participation. *Social Studies of Science, 48*(2), 283-303. doi:10.1177/0306312718770286

Seyfang, G., Park, J. J., & Smith, A. (2013). A thousand flowers blooming? An examination of community energy in the UK. *Energy Policy, 61*, 977-989. doi:10.1016/j.enpol.2013.06.030

Sismondo, S. (2020). Sociotechnical imaginaries: An accidental themed issue. *Social Studies of Science, 50*(4), 505-507. doi:10.1177/0306312720944753

Smith, A., Hargreaves, T., Hielscher, S., Martiskainen, M., & Seyfang, G. (2016). Making the most of community energies: Three perspectives on grassroots innovation. *Environment and Planning A: Economy and Space, 48*(2), 407-432. doi:10.1177/0308518x15597908

Son, H., Kim, M., & Kim, J.-K. (2022). Sustainable process integration of electrification technologies with industrial energy systems. *Energy, 239*, 122060. doi:https://doi.org/10.1016/j.energy.2021.122060

Sovacool, B. K., Bergman, N., Hopkins, D., Jenkins, K. E., Hielscher, S., Goldthau, A., & Brossmann, B. (2020). Imagining sustainable energy and mobility transitions: Valence, temporality, and radicalism in 38 visions of a low-carbon future. *Social Studies of Science, 50*(4), 642-679. doi:10.1177/0306312720915283

Svenska kraftnät. (2023). *Analys elkonsumtion januari 2023*. Retrieved from https://www.svk.se/siteassets/1.om-kraftsystemet/kraftsystemdata/statistik/forandring-av-konsumtion/konsumtionsforandring-januari-2023.pdf

Swedish Energy Agency. (2022). Varje kilowattimme (kWh) räknas. Retrieved from https://www.energimyndigheten.se/varje-kilowattimme-raknas/

Swedish Energy Agency. (2023). *Nuläget på elmarknaden - Januari 2023 - Publicerad 2023-02-07*. Retrieved from

https://www.energimyndigheten.se/490932/globalassets/om-oss/lagesrapporter/elmarknaden/2023/nulaget-pa-elmarknaden-januari-2023.pdf
Velkova, J., Magnusson, D., & Rohracher, H. (2022). Smart Thermostats and the Algorithmic Control of Thermal Comfort. In S. Pink, M. Berg, D. Lupton, & M. Ruckenstein (Eds.), *Everyday Automation - Experiencing and Anticipating Emerging Technologies* (pp. 171-183). New York: Routledge.
von Platten, J. (2022). Energy poverty in Sweden: Using flexibility capital to describe household vulnerability to rising energy prices. *Energy Research & Social Science, 91*, 102746. doi:https://doi.org/10.1016/j.erss.2022.102746
Warneryd, M., & Karltorp, K. (2022). Microgrid communities: disclosing the path to future system-active communities. *Sustainable Futures, 4*, 100079. doi:https://doi.org/10.1016/j.sftr.2022.100079