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Flexibility capital within Swedish multifamily households

A study on energy policy & vulnerability from a bottom-up approach

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Abstract

This study investigates growing need for (demand) flexibility in Swedish multifamily households. This was done by descriptively exploring the correlation between flexibility related experiences and energy vulnerability, by controlling for income. A bottom-up approach was further employed, linking households' flexibility capital, that is, their ability to adjust energy-intense consumption in time - with their opinions on demand-side policies. Both surveys and semi-structured interviews were used, with the latter being emphasized to better understand the flexibility experiences of this group. In this study, two interview groups of different income levels were compared.

To provide descriptive insights, financial resources, measured as annual disposable income, and flexibility capital, was understood with the use of Powells and Fell (2019) flexibility framework. The findings showed little to no indications of energy vulnerability among the interviewed households. Financial resources were a critical determinant of the absence of energy vulnerability in both income groups. The study also found a discrepancy between the households' perceived ability to provide flexibility and their actual ability to commit to it. Additionally, the analysis recognized factors that constrain households' flexibility capital, such as a lack of knowledge, agency, and perceived cost of energy relative to their disposable income. These results correspond to previous research, which indicates an energy justice dimension to demand flexibility policies. Further research is recommended to examine these factors as both barriers and enablers to increasing demand flexibility in Sweden specifically. Furthermore, a larger sample size would be needed to enhance the generalizability of the findings.

Key words: Demand flexibility, Flexibility, Energy vulnerability, Renewable, Energy, Energy Policy

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Explanation list

Flexibility (capital)	**The ability to decrease or shift energy intense consumption in time.**
Demand flexibility	**Policy measures or incentives to influence consumers to decrease or shift electricity intense consumption away from peak demand hours.**
Peak demand hours	**Hours when electricity demand and prices is at its highest.**
Energy vulnerability	**A household's susceptibility to energy poverty**

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1 Introduction

Renewable energy has taken a leading role in the ongoing energy transition happening in many societies around the world. This transition has been facilitated by specific goals and policies, such as the Swedish government's mandate of an electricity certificate system that encouraged renewable energy production and a pledge for net-zero carbon emissions by 2045. As a result, renewable energy has become competitive in the Swedish energy market and now makes up a sizeable portion of the country's electricity generation.

However, a larger share of renewable energy does pose some technical challenges related to supply and demand. First, except for hydropower, renewables' weather-dependent nature makes them unsuitable for meeting peak demand hours without energy storage technologies (Leijon et al. 2010), which can compromise grid stability (Platten 2022). Additionally, as Sweden and other countries continue to transition to renewable energy, sectors such as heating, and transportation will rapidly electrify. Studies show that if every household acquired an electric vehicle, the total electricity demand could increase by as much as 40% (Swing Gustafsson et al. 2018), which will further exacerbate the demand for electricity.

As societies transition to using more renewable energy, a crucial question arises: how will they manage grid balancing as renewables accounts for a larger share of electricity generation? The most prominent solution involves *demand-side flexibility*. This entails measures to incentivize consumers – particularly the households - to decrease and shift electricity consumption away from peak demand hours. In that sense, demand-side flexibility serves the double purpose of addressing the problems inherent to renewables, as well as the projected increase in overall electricity demand. It should therefore not come as a surprise that the Swedish government, on the 2nd of August 2022 took steps to promote flexibility, recognizing the untapped potential within households (Swedish Government, 2022). On that day, the energy and digitalization minister Khashayar Farmanbar stated that:

> *"..demand-side flexibility allows households and companies to have an important role in the green transition and to decrease high electricity bills"*[1]

As can be read from Farmanbars statement, the emerging policies reflects a growing trend of households being relegated a larger role in the energy system. Indeed, such a shift is justified by data showing that European households are responsible for a significant portion of electricity demand, including up to 60% of peak demand, (Barton et al. 2013), which is a trend largely reflected in Sweden as

[1] My own translation, Uppdrag att främja ett mer flexibelt elsystem - Regeringen.se [Downloaded 2023-12-25]

well (SCB., 2019. The issue at hand, however, is that while demand flexibility can reduce the need for supplier investments in energy infrastructure to meet peak energy demand (Fjellså et al. 2021a) - it also means that households are taking on a greater burden in the energy system - which raises concerns about energy justice. For example, low-income households may not have the social or technological resources to adjust their energy usage in response to these policies, which could lead to increased energy costs and potential energy poverty. To address these concerns, it is important for policymakers to consider the potential impact of demand flexibility policies on different groups within the population and develop targeted solutions to ensure that everyone can benefit from the green energy transition.

1.1 Problem formulation

The transition of Sweden's energy system has shown signs of shifting the burden from the supply side to the demand side, enabled by policies that promote flexibility in the energy sector as a whole, and households in particular (Fjellså et al. 2021a).While demand-side policies are generally seen as a good way to promote investment in renewable energy to tackle climate change and other environmental issues, there have been growing concerns that such policies could exacerbate inequalities (Bouzarovski et al. 2017). These inequalities may arise between and within households in Sweden, since each household own socio-cultural and socio-technological context (Platten, 2022). In other words, different households have different abilities to respond to policies intent on capitalizing on flexibility. Indeed, previous research suggests that energy transition changes could harm the well-being of social groups at risk of energy poverty, even if such changes ultimately lead to "more efficient and affordable energy use" (Ibid, p. 21) in the long-term as the economy becomes more decarbonized (Jerneck and Olsson 2008).

1.2 Purpose and aim

For these reasons, I aim to focus the study on the central concept of flexibility at the household level to discern in what way flexibility has a bearing
on energy vulnerability. While there have been some studies on household flexibility in Sweden – henceforward addressed as flexibility capital - they have mainly focused on single-family households (Platten 2022). I therefore intend to complement that research by taking a descriptive approach to the study of multi-family households. Multifamliy households will be studied during the energy crisis where it has become increasingly clear that flexibility capital, as in, the ability to decrease or shift one's electricity-intense consumption in time, has had a significant impact on household finances. In other words, the current conditions make it

especially important to shed light on multi-family household flexibility. Having said that, this study does not intend to make demand flexibility policies the focal object of analysis since they are still relatively underutilized.
(Energimarknadsinspektionen). Instead, I intend to analyse the significance of such policies for households by surveying and conducting interviews to reveal household flexibility capital. Flexibility capital should further reveal to what extent energy vulnerability is experienced within Swedish multifamily households when accounting for household income.

Lastly, I intend to measure household perceptions on demand flexibility policies. I am hopeful that this participatory approach to policy will both empower households to make their voices heard as an actor within the energy system, all while providing valuable insights on themes such as policy acceptability to inform future policymaking.

1.3 Research questions

With the problem formulation in mind, and to complete the purpose and aims of this paper, I will attempt to answer the following questions:

Q1 - How do (multi-family) Swedish households within SE3-4 experience their ability to provide flexibility?

- Q2 – Accounting for annual disposable income, to what extent do low flexibility within multifamily households involve a state of energy vulnerability?
- Q3 – How do households perceive demand flexibility initiatives?

The research questions of this study are descriptive and therefore provides a basis for descriptive inferences. Q1 is highlighted since it is the primary focus of this study, and it is through the experiences gathered from Q1, that we are able to understand the potential impacts of demand flexibility policies. Q2 was included since the correlation between low flexibility and energy vulnerability is seemingly dependent ones financial resources. This study therefore controls for income by describing its role and envisioning it as a conditional variable. Lastly, the third question (Q3) connects household experiences from Q1, to perceptions on energy policy.

2 Background

This chapter will begin with a section that motivates why policy studies from a bottom-up approach can be beneficial. After that, I will elaborate on the two relevant demand flexibility measures of this study. Lastly, it is important to contextualize the study's setting through the specific circumstances that the Swedish households currently inhabit. For that reason, I will briefly summarize the energy crisis, the Swedish energy landscape, and why the energy crisis has affected the southern households in particular.

2.1 Why study policy from the household perspective?

What is "political", and where does it take place? Leftwich and Callinicos (1984) and Hay (2002) understood it as an arena or a process. The arena definition refers to the formal operations of politics in government and the actors that attempt to influence it within limited arenas, such as political parties and interest groups. The process definition, on the other hand, is broader yet less precise, it reflects the idea that:"..power is inscribed in all social processes" (Lowndes et al. 2018, p. 7) - including within the sphere of daily life. On one hand, this study will examine those daily experiences which is in line with the perspective of political sociology, a sub-discipline that focuses on power-based relationships between social structures, culture, and individuals, often from a bottom-up approach. With such a perspective in mind, one can explore how power in the form of policies: "..quietly wraps around systems of inequality that constructs differences in who has what, when, and how" (Dobratz et al. 2016, p. 9). Households, in this sense, can be viewed as a system of inequality given that all households per default have varying internal and external capabilities to respond to energy policies since they inhabit different socio-cultural contexts. The consequences of policy, then, can be understood by studying those very households subject to them.

On the other hand, the bottom-up approach can further contribute to a broader discussion involving the institutions that households are a part of, such as the energy system. The energy system consists of a range of actors that are mutually competitive and dependent each other. Household consumers, for example, compete for energy resources with industrial actors that are typically engaged in energy intense activities. These two actor-groups are also mutually dependent on energy suppliers who themselves are subject to the laws and regulations enforced by public authorities. Such a collection of interactions tend to produce stable patterns of behaviour over time, and can be viewed as an institution (Lowndes and

Roberts 2013). It can be argued, however, that subsidies and changes in energy policy in recent years these have resulted in a more dynamic energy institution. Indeed, as household flexibility becomes increasingly capitalized on through policy (section 1-1.1), those households with the least flexibility capital may become subjugated to other actors within the same institution in terms of leverage and bargaining power. Consequently, demand flexibility policies can be viewed as an attempt at institutional change with forthgoing consequences.

2.2 Demand flexibility policies in Sweden

There is a broad agreement that demand-side policies can encourage households to reduce or shift their energy consumption to low demand hours by balancing energy supply and demand and promoting efficient energy consumption (D'Ettorre et al. 2022). In doing so, demand flexibility would essentially support a renewable energy transition (Energimarknadsinspektionen). In Sweden, several demand flexibility measures are currently in place, with *power tariffs* and *hourly agreements* being the most relevant for this study.

Power tariffs involves a direct tax on energy consumers engaging in energy-intensive activities at peak demand hours to spread out electricity consumption throughout the day, thereby contributing to a less strained electricity grid (Energimarknadsinspektionen). The government agency known as the Swedish Energy Market Inspectorate are currently implementing these measures up until 2027.

Hourly agreements were proposed in 2012 to give households the opportunity to enter into new forms of electricity agreements and strengthen their position as consumers on the electricity market (Swedish Parliament, Prop. 2011/12:98). Hourly metering measures electricity consumption on an hourly basis and bills households accordingly, giving them the chance to reduce their total electricity consumption and change their consumption pattern (Ibid, Prop. 2011/12:98; Ellag 1997:857) The expectation was that this would increase energy awareness and encourage frugal practices, ultimately reducing energy costs for households (Prop. 2011/12:98). Additionally, a larger proportion of hourly metered electricity consumers in the long run would contribute to lower power output during critical periods (Swedish parliament, Prop. 2011/12:98). Critical periods which refer to peak-demand periods when variable energy sources, such as wind and solar, are expected to contribute to a low power output. Nevertheless, despite the potential benefits to the electricity grid, hourly agreements have not yet become an ordinary form of agreement among the Swedish population[2][3]. This may change moving forward, however, as recent price surges in ordinary electricity agreements have increased the shift towards hourly agreements.

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[2] In southern Sweden, where most of the Swedish population reside, less than percent of the households have entered into hourly electricity agreements as of October 2022 according to the statistical census bureau.
[3] The common forms of electricity agreements in Sweden are the fixed and variable agreements.

2.3 How can households contribute with flexibility?

Households have two means of responding to demand flexibility policies, such as the power tariff or the hourly agreement, and they are known as social and technological flexibility. The goal of social and technological flexibility is to decrease or shift one's energy-intense consumption in time. For

The provision of social flexibility is dependent on one's behaviours, habits, and social practices. It is commonly addressed by avoiding or minimizing energy intense activities. This includes not preparing meals for extended hours or charging the electric vehicle at night rather than during the day. Ultimately, social flexibility is intricately linked to social routines, and the provision of flexibility therefore requires that the household in question recognizes its negative energy practices by adopting frugal practices, either through its own effort or through the effort of external actors.

Contrary to social flexibility where avoidance and frugal behaviour are recurring elements, technological flexibility entails financial investments to allow for an energy efficient household. Such investments involve investments into building insulation, solar panels, and into more efficient household devices.

Having said that, it was previously established that households reside within different socioeconomic and cultural contexts and have various internal and external capacities in regard to the provision of flexibility. Put differently, it can be safely assumed that depending on a household condition, some households may be less equipped than others to increase their social flexibility. Similarly, depending on internal abilities such as financial resources relative to external factors affecting the cost of energy (such as demand-side policies or a volatile energy market), some households will likely find it difficult increasing their technological flexibility. This problematisation is a crucial point permeating the study, and I will now elaborate on an external factor affecting the cost of energy that does not involve demand-side policies.

2.4 The energy crisis in (southern) Sweden

In Sweden, the energy crisis has had an uneven impact on the country. Although European market integration and the marginal cost of gas has had a large external role in the electricity price-setting, domestic factors need to be considered. For one, Sweden has, as previously mentioned, integrated a large amount of renewable energy. This has led to a variable energy system which is reflected in price-lows as well as price peaks (Energimarknaderna 2021, p. 21-22).

Secondly, the country's transmission grid has experienced difficulties supplying electricity from the north to the southern parts of the country. Sweden's hydro power which has a key role meeting overall and peak-demand along with considerable

amounts of wind power is located up north. This has become a nuisance for the Swedish grid since most of the country's household electricity demand comes from electricity SE 3-4, which is in the country's southern regions.

Given these domestic factors, and compared to its northern counterpart, the southern regions have had a challenging time balancing energy supply and demand. This has, in essence, made the southern regions more dependent on expensively priced energy due to European energy market integration. In response, the distributed subsidies by the Swedish government have primarily targeted SE3-4.

2.5 The relationship between household flexibility and energy vulnerability

Despite the current energy conditions experienced in Sweden, historically, the Swedish households have had a good chance of managing financially. In fact, surveys regularly identify Sweden amongst the least energy poor countries throughout the EU. This has likely to do with a combination of reasons. For one, since the cost of heating and water has typically been included in the rent – also known as warm rent – landlords have, as a rule of thumb, made the effort to make the household stock energy efficient to decrease operating costs. Additionally, Sweden has embraced the welfare state model. (Platten 2022) for example, argues that citizens have historically been able to benefit from welfare services which has effectively addressed energy poverty concerns. In fact, the social security system in Sweden has been sufficiently robust that the concept of energy poverty has rarely been defined and subject to public discourse (Ibid).

However, circumstances change as has become evident by recent events. Indeed, the energy crisis, entailing volatile electricity prices – has created a state in which people may move in and out of energy poverty. Platten (2022) highlights this temporal aspect as an important characteristic of energy vulnerability, which is a conceptualisation that aims to go beyond the mere traditional focus on affordability. To conclude, it can be said that although there is a historical precedence for low rates of energy poverty in Sweden, recent conditions indicate that a substantial amount of the general population may be considered energy vulnerable depending on their household flexibility.

3 Previous research

This chapter will provide a summarized account of the existing research on demand flexibility. Additionally, and most relevant for this study, I will elaborate on the academic research concerning the connection between demand flexibility and the households.

3.1 The need for demand flexibility

Most of the previous research on demand flexibility have typically emphasized theoretical work, with the aim of assessing flexibility potential within demand-side sectors, on one hand, and how demand flexibility may impact power systems, grid operators, and consumers, on the other hand (Herre et al. 2022; D'Ettorre et al. 2022). Söder et al. (2018) summarized several studies concerning demand flexibility potential within different northern European countries, including Sweden, Norway, Denmark, Finland, Estonia, Latvia and Lithuania. Accounting for the commercial, industrial, and residential sectors, the researchers estimated that a combined technical potential between 12-23 Gigawatt (GW), and a peak load potential of 77 GW could be achieved. Similarly, indicating a high potential in Germany, (Gils 2016) found through a modelling and case study approach that demand flexibility could economically substitute up to 10 GW of power plants[4].

Concerning its application to the energy system and grid operators, Managan (2014) suggests that demand flexibility helps electricity grid operators address several challenges, among them, the need to manage an increasing energy demand relative to the speed new supply is being built. Moreover, referring to the United States specifically, Managan (Ibid) notes that old power plants are currently retiring which paves the way for demand flexibility to make up for the lack of expected energy supply.

In regard to its impact on consumers and the decarbonisation of the energy markets, (Torriti 2022) highlights that demand flexibility could solve a current problem with conventional energy markets. During peak electricity demand periods, power plants with high greenhouse gas emissions (GHG) and operation costs are typically activated and bid in. By incentivizing a societal wide decrease or shifts of electricity consumption to hours of low demand, demand flexibility, then,

[4] For reference, a typical nuclear reactor has an installed capacity of between 0.8 – 1.2 GW.

serve the double purpose of reducing both GHG and the overall cost of electricity for consumers.

Another area of study concerning demand flexibility involves its contribution to grid stability. Research shows that the renewable energy transition has necessitated a larger emphasis on flexibility to maintain grid stability (Li and Pye 2018);Kirkerud et al 2021; Agbonaye et al. (2022). Indeed, according to D'Ettorre et al. (2022), a larger integration of wind and solar provide fewer spinning reserves[5] and thus reduce system stability. Abgonbaye et al (2022) argued further that in the UK, where renewable energy accounted for 42.9% of the electricity generation in 2020, a significant amount of wind power generation found itself being dumped because of systemwide balancing or network issues. Put differently, this means that excess wind generation need to be curtailed to guarantee a stable grid. In the same study, they showed that the curtailment of excess wind generation in Scotland between 2020 and 2021 amounted to a cost of £350 million in constraint payments to reject an excess of 5.2 Terawatt hours (TWh) of wind energy (Ibid). Parrish et al. (2020) then, argues that enhancing grid flexibility is a key factor in minimising the costs of renewable energy integration.

3.2 Household flexibility

The need to align demand with supply in the energy sector is not new, and measures to achieve this date back over a century, albeit rarely targeting households specifically (Powells and Fell, 2019). What is new is the active involvement of energy consumers in all sectors, enabled by new measures (D'Ettorre et al. 2022). Studies on the residential sectors indicate that households are a large contributor to both general and peak energy demand. Fleter et al. (2017) for example, found that heating and cooling applications in Europe account for about 51 % of the total final energy demand. Similarly, (Barton et al. 2013) found that households are responsible for about 60% of peak demand. Although these studies included forms of energy other than electricity, they did, nevertheless, show that it will be necessary for advocates of demand flexibility to incentivize households to become involved.

(Parag 2021), for example, researched households' willingness to join a flexibility measure program known as time-of-use pricing. These measures sought to reflect the real availability and cost of electricity. Simply put, it involved a fixed tariff for households at various times of the day, or different days of the week (see section 2.2, power tariff, for a similar measure). While the household participants experienced negative reactions, they were, nonetheless, more willing to take part in the program if the national benefits were effectively communicated (Ibid).

A relatively recent research area has highlighted energy justice concerns

[5] Spinning reserves can be found in electricity generators, which are devices that converts energy, such as mechanical energy from wind turbines or chemical energy from fossil fuels into electricity. Heavy generators such as those found in nuclear or fossil fuel typically balance the electricity grid. Renewable power plants, in contrast, have lighter generators and do not contribute to system-wide stability.

accompanying demand flexibility policies. Thomas (et al. 2020) for example, researched deliberative workshops where citizens identified, interpreted, and motivated their concerns with flexible energy systems. Among several findings, the researchers found that the concern for vulnerable groups and the recognition of their needs was a common salient discourse. Such concerns mirrors the work of Powells and Fell (2019) on flexibility capital, who argued that a trend can be seen where flexibility is becoming increasingly economized across various sectors – including the residential energy sector. Due to households residing within different socio-cultural and technological conditions, they argued, then, that flexibility policies may reinforce existing advantages and harms within households.

(Korsnes and Throndsen 2021) continued the research on flexibility capital by investigating prosumers, that is, households with the ability to both produce and consume energy (as opposed to only consuming). They found that smart technology and solar panels seemingly affected the way daily life was organized. The results indicated a divergence in the sense that households at times benefitted from these new arrangements, while they, at other times, proved detriment because of an increase in household work. Indeed, research by Rinkinen et al. (2019) point to similar results that taking over parts of the supply chain to provide flexibility, as prosumers tend to do, implies more work.

Moreover, flexibility policies may have gendered consequences (Carlsson-Kanyama and Lindén 2007). Johnson (2020) for example, sought to reveal gender dynamics within the households by conducting several interviews and focus groups. While the research is still relatively scarce, there are indications that flexibility policies may entail an increased domestic work (Korsnes and Throndsen 2021) since many energy-demand chores are performed by women (Johnson 2020)

Finally, previous research also indicates that households with low flexibility capital may be susceptible to energy vulnerability/poverty. Powells and Fell (2019) theorize that those with low flexibility capital may either reduce the consumption of other important goods, such as food or heat, or restrict electricity consumption in the first place. Research on student households, found that electricity use is generally ´locked in´ due to daily practices and schedules, making them more likely to experience low flexibility capital (Fjellså et al. 2021a). These households may be more exposed to a situation of energy poverty particularly, as Fjellså (et al. 2021a, p.3) puts it*:* "If flexibility becomes a commodity". Referring to the relationship between flexibility and energy vulnerability in Sweden, Platten (2022, p.36) notes that: "if energy poverty in Sweden is mainly exposed at price peaks, it follows that the ability to dodge price peaks becomes an important quality among households to reduce their vulnerability to energy poverty". Indeed, this argument is mirrored by Powells & Fell (2019) who notes that dodging said price peaks, then, are heavily dependent on one's capacity for flexibility as that allows households to shift energy consumption in time through changes in intensity or a switch of energy source.

Building on the work of Powells and Fell (2019) and Bouzarovski et al. (2017), Platten (2022) sought to shed light on Swedish households vulnerability to energy poverty. The central part of Plattens energy vulnerability framework is that it recognises a temporal aspect, namely, that households may: "Move in and out of a

state of energy poverty as internal and external circumstances change" (Platten 2022, p. 2). This temporal aspect constitutes energy vulnerability, and it is directly linked to flexibility capital, which will be applied to my study as well. Crucially, Platten (2022) hypothesized that vulnerabilities in Sweden have become exposed due to current changes in external factors, such as the volatile winter at the end of 2021 and the war in Ukraine initiated by Russia. External factors are expected to shift parts of the burden from the producer/supplier to the consumer and may therefore indirectly penalize those that cannot provide enough flexibility, and it follows that external factors will become further internalized (Platten 2022). A similar logic can be applied to demand flexibility policies, which too, is expected to shift parts of the burden from the producer/supplier to the consumer. Plattens findings on Swedish single-famliy households (not to be confused with multifamily households which I intend to study) have been important to contextualize how Swedish energy vulnerabilities may manifest following changes in external factors such as new policies or changes to energy conditions.

4 Theory chapter

This chapter will clarify central concepts of interest, such as demand flexibility, flexibility capital, and energy vulnerability. Further, I will present the analytical framework which has guided this study.

4.1 Theorizing flexibility & energy vulnerability

4.1.1 Flexibility

Demand flexibility have different definitions depending on which perspective one uses, and which actors are given precedence (Zagerholm et al. 2021). In this study - where household consumers are given precedence - demand flexibility can be understood as "a voluntary change in electricity demand from the grid for shorter or longer periods as a result of a type of incentive" (Ibid, p. 13). The incentive in question are the policies that were elaborated in section (..), namely, hourly agreements and power tariffs. The voluntary aspect of the definition is not unproblematic, however, since power tariffs are externally enforced measures and cannot be considered voluntary. Therefore, a proper definition of demand flexibility would entail, a voluntary or involuntary change in electricity demand from the grid for shorter or longer periods as a result of a type of incentive.

Further, the concept of flexibility capital, which is essential to this study, describes household responsiveness. It is commonly defined as "the capacity to responsively change patterns of interaction with a system to support the operation of that system" (Ibid, p. 57). There are many terms to unpack here. These supposed interactions with the “system”, for example, refers to the electricity grid, and the supposed “interactions” with the grid involve shifting or decreasing electricity-intensive consumption to hours of low demand. In reality, these interactions typically involve social or technological practices (see section..). Additionally, the term electricity-intensive refers to activities which consume large quantities of electricity at a given time. This include, but is not limited to; Cooking, starting the laundry machine or charging ones electric vehicle. Naturally, it follows that these activities can be limited through technological or social means.

With the terms now unpacked, it is becomes logical to reframe the initial definition so as to fit it to the objective of the study. Therefore, flexibility capital

will henceforward be defined as “the households ability to decrease or shift electricity intense activities to hours of low demand”.

The concepts of demand flexibility and flexibility can be further understood when viewed from a societal lens. According to Powells & Fell (2019), smart-energy systems create conditions for flexibility to be valued, enabling it to be capitalized. Therefore, an understanding of flexibility capital is dependent on its degree of economization. Their research shows that flexibility capital is unevenly distributed within and across societies (such as between individuals, households, businesses, and communities), but it is persistently sought after by the state and the market to stabilize the grid or to profit, respectively. Hence, flexibility can be framed as an energy justice issue, or as the authors term it, flexibility justice (Ibid). As mature energy systems in the global north integrate renewable energy, flexibility justice provides a way of thinking about "How best to recognize and include those most at risk of disadvantage in designing progressive energy service provision" (Ibid, p. 59.). To illustrate, the authors draw upon the lessons from the labour sector to showcase that flexibility measures within the gig-economy have been plagued by gendered and racialized inequalities and have posed risks to employment standards (Ibid;Eriksson, 2022). Although it is currently unclear to what degree labour market experiences are transferable to the energy sector, Powells and Fell (2019) note that flexibility is "neither inherently emancipatory nor pernicious" (Ibid, p. 58). These remarks imply that although flexibility can neither be regarded as an inherent good or bad within the energy sector, it may be experienced either way depending on the socio-cultural or socio-technological landscape in which it has become increasingly valued. Hence, underpinning this study, it can be conducive to study the: “flexibility-related lived experiences, (in)conveniences and subtle changes to quality and control over one´s life that often go under the radar of much research” (Ibid, p.58). This supposed “control” over one’s life refers to agency which may be controlled by external actors. This comes with energy justice implications, and agency, then, can be defined as the households perceived ability to exert control over ones social or technological flexibility. Having said that, the uneven distribution of flexibility capital within and across societies which lies at the core of Powells and Fells argument, presupposes that some household consumers are better off than others, with some households experiencing energy poverty, while others are experience energy vulnerability.

4.1.2 Energy vulnerability

As have been briefly touched on (see section) Energy vulnerability indicates one's likelihood of experiencing energy poverty, and although there is no common definition of energy poverty within the EU, the UK has commonly defined it as the disproportionate cost of energy in relation to one's disposable income (Li and Pye 2018). This usually means that a household is energy poor if ten percent or more of that household's disposable income are spent on energy bills (Ibid, p. 19; Platten

2022, p. 2). This is, however, a static understanding of energy poverty that does not consider households' ability to fend off the cost of energy through responsiveness as in flexibility capital (Platten 2022). Furthermore, measuring energy poverty as ten percent of one's disposable income could be misleading since affluent households with an energy-intensive lifestyle would now be considered energy poor.

A more nuanced view, which has developed in recent years, is the consideration of risk factors (Platten 2022). Bouzarovski et al. (2017) consider both internal and external factors in their energy vulnerability framework to involve energy deprivation in relation to all household energy services. These six factors are energy efficiency, needs, access, practices, affordability, and flexibility. While these concepts together make up the different dimensions of energy vulnerability, my study emphasizes the interaction between financial resources and flexibility. As such, energy vulnerability is defined as: a household's susceptibility to energy poverty through a dysfunctional interaction between flexibility capital and financial resources.

4.2 Analytical framework

I chose to focus on flexibility capital and financial resources out of the six risk factors proposed by Bouzarovski energy vulnerability framework (et al. 2017). For the analysis, Powells & Fell's (2019) flexibility framework which has emphasized the connection between flexibility capital and financial resources, will be guiding (see figure 2). Having said that, the framework will not strictly guide the analysis of this study since it is a generalized framework. Indeed, there are reasons to suspect that the frameworks' predicted results do not necessarily apply to Swedish multifamily households since they, unlike most countries, have warm rent (see section 2.4). This would explain why Platten (2022), who herself made use of Powells & Fells framework, decided to apply it to single-famliy households which typically have cold rent, rather than multifamily households. Nevertheless, the framework provides an added value by simplifying theorethical complexities. I therefore expect the framework to bring clarity to the emphasized interaction between flexibility and financial resources as I attempt to interpret the empirical findings during the analysis stage.

Powells & Fells framework consists of four quadrants, where affluence is positioned on a vertical axis and flexibility capital on a horizontal axis. The top and lower left quadrants represent a state in which consumers are unable to be flexible and are therefore subject to unavoidable additional costs. The consequence of being positioned in the left-hand quadrant differ, however, depending on the initial affluence level of the household in question. Indeed, the top-left quadrant shows that the combination high affluence and low flexibility has a small bearing on comfort and convenience, despite the financial penalties incurred for being inflexible. On the other hand, in the bottom-left quadrant, low affluence along with

low flexibility increases the likelihood that people find themselves denied access to smart technology, experience a lack of agency, and see an increased tension between energy costs and comfort and convenience (heating, access to smart appliances, etc). Households in this quadrant are understood as energy vulnerable.

In the right-hand quadrant, the top-right represents an ideal state for a household within the energy sector, where flexibility capital is largely technologically derived because of high affluence levels. Household positioned here are expected to have higher agency and can provide further flexibility to the grid as solar cells, battery storage or smart appliances are installed. In contrast, the bottom-right showcase a scenario where flexibility is likely socially derived due to low affluence levels, which may affect household convenience since socially derived flexibility entails changes to social practices, such as habits and behaviors. Having said that, while the bottom-right quadrant involves a tension between energy costs and comfort, the probability of having to choose one over the other is likely low (Powells and Fell 2019).

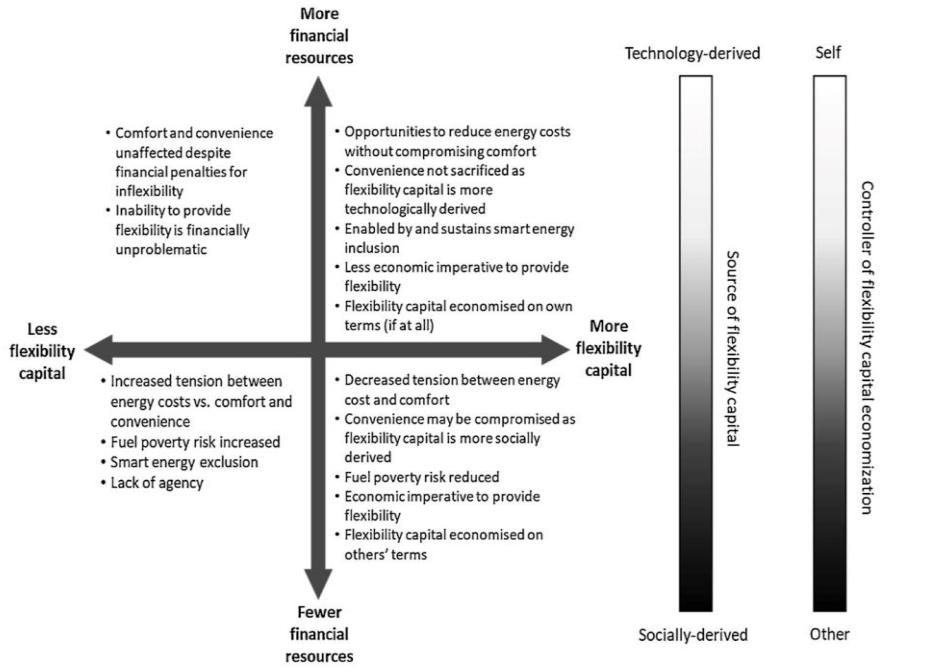


Fig. 1. Generalized representation of the interaction between flexibility capital and financial resources (affluence).

Figure 1. Representation of the interaction between flexibility and financial resources
Source: Powells & Fell (2019)

To summarize, Powells & Fells theorize four different type of population groups within the framework. Of these four, two stand out in particular: 1) Those groups that largely depend on their income to mitigate the costs of being inflexible, and 2), Those groups that largely depend on their flexibility capital to mitigate the costs of being inflexibile. These groups will be paid special attention to in my own analysis as I compare two income groups (see section 5.5, data analysis & inference strategy).

5 Methodology

This chapters by clarifying the research design. Short reflections on data gatherings, the population through a strategic selection will then be presented. Chapter 5 goes on to elaborate how I intend to answer the research questions through inferences and by operationalizing theoretical concepts. It ends by considering methodlogical limitations.

5.1 Research design

I employed a mixed-methods approach in this study, with a focus on descriptive, qualitative aspects. While quantitative elements were included in the study, such as a survey and a subsequent analysis based on descriptive statistics, the focus lied on semi-structured interviews to shed light on a small number of empirical observations, informed and guided by theoretical concepts (King et al. 1994). In doing so, I was able to describe households' flexibility-related experiences in a way that illuminated patterns, trends, and relationships among variables such as energy low flexibility, energy vulnerability, and income.

It should be noted that descriptive studies have an inherent value within the social sciences. For example, King (et al. 1994) comments that inferences can be made by "using observations from the world to learn about other unobserved facts". These unobserved facts are often concepts, ideas, or social structures. They are facts that cannot be directly observed but are nonetheless real, and do not always "speak for themselves" (Brady and Collier 2010). It follows, then, that descriptive inferences can expose phenomena that have previously been given little attention (Esaiasson et al. 2017). In this study, I will attempt to map such phenomena by developing new concepts or reinforcing existing ones.

Further, in order to describe the role of disposable income, and how it relates to household flexibility and energy vulnerability (see research question 2), I carefully selected interviewees through the survey respondents. This approach aided the generalizability of the study which will be further elaborated in sub section 5.2.2. The survey produced 22 variables, with some variables having yes or no answers while others had numerical values. The interviewees were selected on 11 out of the 22 variables, which were believed most relevant and categorized as general or theoretically derived (see appendix B). In contrast to general variables which gave an idea of the selected population, the theoretically derived variables were included to gather theory driven data based on previous research (chapter 3) and applied theoretical framework (chapter 4, section 4.2) Further, I divided the interview respondents into two groups based on their annual disposable income, with all other

variable values held constant between groups A and B. Group A indicated an annual disposable income of 300-500 thousand krona, and group B had 500 thousand or more.

Having said that, this study – like all studies – is dependent on how the nature of the world is perceived, and how it can be inquired and understood, respectively. This is called ontology and epistemology, and it greatly influences how the study is shaped, conducted, and ultimately, what can be claimed (Lowndes et al. 2018). Concerning ontology, I ascribe to a foundationalist position that favours both the quantitative and qualitative methods. This allowed me to gather data via multiple sources to ensure internal validity. Furthermore, from an epistemological point of view, the mixed-methods approach suggests a critical realist position in that the world is ontologically understood as having objective properties independent of the observer, while also admitting to deep structural relationships that cannot be directly observed, such as social meanings or the concept of power, but where the consequences can be felt. However, although I methodologically ascribe to critical realism, there is no denying that this particular study privileged direct observations rather than meaning, reflecting my positivist epistemological position in analysing and interpreting the material.

5.2 Data gathering

This section elaborates on the data gathering methods that were briefly mentioned in section 5.1. I used both the survey research method and the semi-structured interview which together aided in the inference strategies of this study. These inference strategies will be elaborated in section 5.4.

5.2.1 Survey research method

Surveys are typically constructed with structured questions and answer-categories that the respondent answers themselves. The responses were collected through a non-randomized, self-selection approach with the help of a housing company known as *Lunds kommunala fastighetsbolag*, and through social media tenant groups. The survey came with several advantages and distinct qualities. For one, it was used to gather a relatively large amount of primary data in a brief time span (Kvale, 1994). This amounted to 50 survey responses. Secondly, by keeping the questions and answer categories short and concise, I was able to capture frequencies, that is, how often an answer occurs or do not occur within a given population (Ibid). All questions and answers were framed and asked in the same way which made it easier to compare the results across the respondents.

5.2.2 Semi-structured interview

Unlike the survey method where the aim is to shed light on how frequently occurring certain answers are within a given population, the semi-structured interview enabled me to gather qualitative data, and as Steinar Kvale puts it, “elicit spontaneous descriptions that reside in the interviewees own reality” (Esaiasson et al. 2017) These descriptions of one's own reality can be difficult to access through other means. 9 interviewees of the respondent type were selected based on a set of variables (see section 5.1) where the focus was on the personal, subjective experience. This can be contrasted with the informant type which typically focuses on key events or persons. The semi-structured interview was therefore considered a suitable choice to allow me to take on a more active role as a researcher. I was able ask follow-up questions which in turn allowed for an elevated level of complexity in the answers. This became helpful when the questions dealt with social practices, behaviours, habits and other concepts of similar complexity.

5.2.3 Generalizing the findings

The semi-structured interview was not optimal to generalize the findings in a traditional, statistical sense, and the survey was limited in terms of received responses and the non-randomized approach. However, given that the methodological focus was on the semi-structured interview, where the focus was on thick descriptions, I would argue the possibility of generalizing the findings to abstract phenomena. Generalising the findings in this way, to paraphrase Essaiason et al. (2017), involves the premise that there are limited ways of interpreting a phenomena or experience. In this sense, the population of this study constitute the main interpretations or conceptions of flexibility, energy vulnerability, income, and flexibility policies that can be claimed to exist within multifamily households (see strategic selection, 5.3).

5.3 Strategic selection

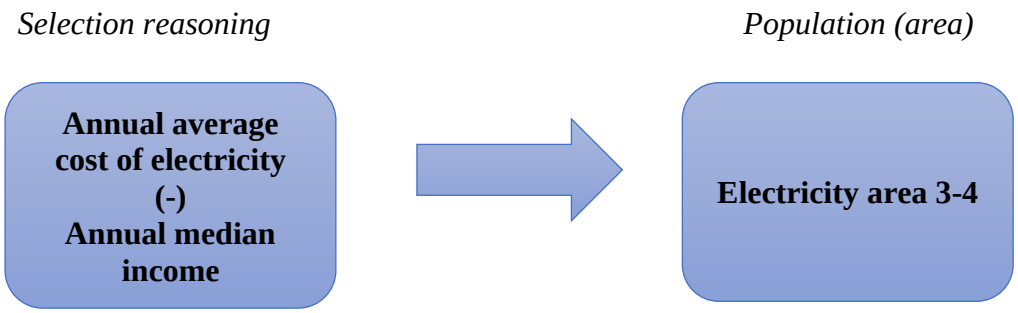
In this section I will discuss the selection process of the studied population.

5.3.1 Electricity area 3–4

Southern Sweden was previously defined as electricity area 3-4 (SE3-SE4) in the contextualization chapter, implying that those areas likely to experience energy.

vulnerability, as opposed to SE1-2. In short, these areas were chosen based on the historical cost of electricity during a nine month time-frame[6], minus the annual median income of households (see figure 3). The first step in the selection process was to differentiate the electricity areas that stood out, namely, SE3 from SE4.

Figure 2: Macro reasoning



The historical market electricity prices (known as spot prices) in SE3-4 indicated that SE4 had experienced higher costs of electricity on average[7]. Though a useful starting point, it was not sufficient to exclusively rely on the cost of electricity as a sole indicator to discern vulnerability within households. To that end, I decided to look at annual median income and compare it between the electricity areas[8].

The next step was to determine whether the annual median income which was higher in SE4, made up for the higher electricity costs. The short answer was yes, and the result was a 2 023 kr total difference to the detriment of SE3, or about 168kr per month[9]. While these differences were not exactly negligible, they were not significant enough to motivate the exclusion of one of the two electricity areas in the study.

5.3.2 Multifamily households

When deciding on the population group, I considered multifamily households[10] and single-family households[11], as they are the most common housing forms in Sweden. To narrow the focus, I took three factors into account: external exposure, agency,

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[6] From January 2022 to September 2022. The timeframe was used to determine the yearly average cost of electricity.
[7] As of September 2022, the average cost of electricity excluding taxes and levies was 1.61 Swedish krona/kilowatt hour (kr/kWh) for SE4, and 1.29 kr/kWh for SE3. The reference electricity usage (3500 kilowatt hour/year) corresponded to a middle sized apartment. By multiplying the average cost of electricity with 3500 kw/h (corresponding to the electricity consumption of a middle-sized apartment), it was found that SE4 paid 1484kr more for electricity, or about 124kr more per month.
[8] It was found that SE3 had an annual median income of 302 145kr, while SE4 had 305 652kr, a difference of 3507kr in favour of SE4.
[9] The cost of electricity in SE4 within the studied timeframe was 1484kr more than in SE3, but SE4 had a 3507kr higher annual median income than SE3. 3507 – 1484 = 2 023 kr to the detriment of SE3.
[10] Multifamily households are residential buildings where separate housing units are contained within the same building. This typically includes apartments and cohousing.
[11] Unlike the former, single-family only contain one household unit. They can be connected to other buildings or detached as separate houses.

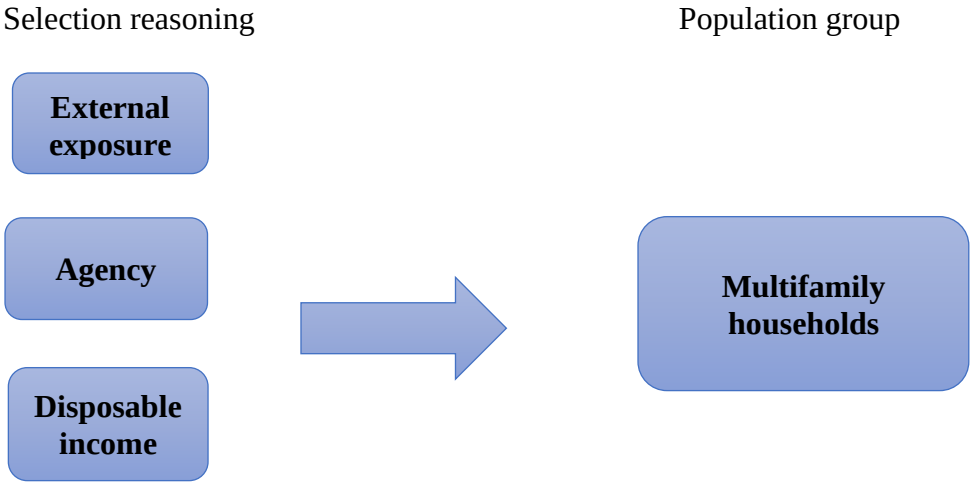
and disposable income. External exposure refers to the vulnerability of households to external factors, which includes, but is not limited to policies or volatile energy prices. Agency refers to a household's ability to determine its own flexibility capital, and disposable income is the final household income after taxes.

External exposure was assessed by comparing the use of warm rent and cold rent in the two population groups. In Sweden, warm rent dominates multifamily households, and this means that heating and water costs are included in the monthly rent. The same cannot be said for single-family households where cold rent is common, which makes them more vulnerable to external exposure.

Regarding agency, multifamily households are subject to building regulations and landlord decisions. As such, they are unlikely to exert control over their technological flexibility in the sense that they can install solar panels or improve building insulation on their own. This can be contrasted with single-family households, who typically own their household and are without a landlord.

Concerning disposable income, it is possible that multifamily households are more susceptible to energy vulnerability as they make up a larger proportion of the lower-income groups in Sweden. However, when compared to single-family households, they are generally smaller in size and come with warm rent, which may result in lower operating costs. This makes disposable income a relative factor. Ultimately, it was challenging to determine the likelihood of energy vulnerability within either household type based on these three factors alone. Nevertheless, I chose to focus on multifamily households, in part to complement previous research, and in part since these households are assumed to rely on landlords/housing associations while also making up a large portion of the Swedish society's lower income groups.

Figure 3: Micro reasoning



5.4 Descriptive inferences

This section makes transparent the underlying approach to how I intend to answer research questions 1, 2 and 3 through descriptive inferences. Naturally, inferences can only be made with the operationalization of central concepts. This will be elaborated in section 5.7.

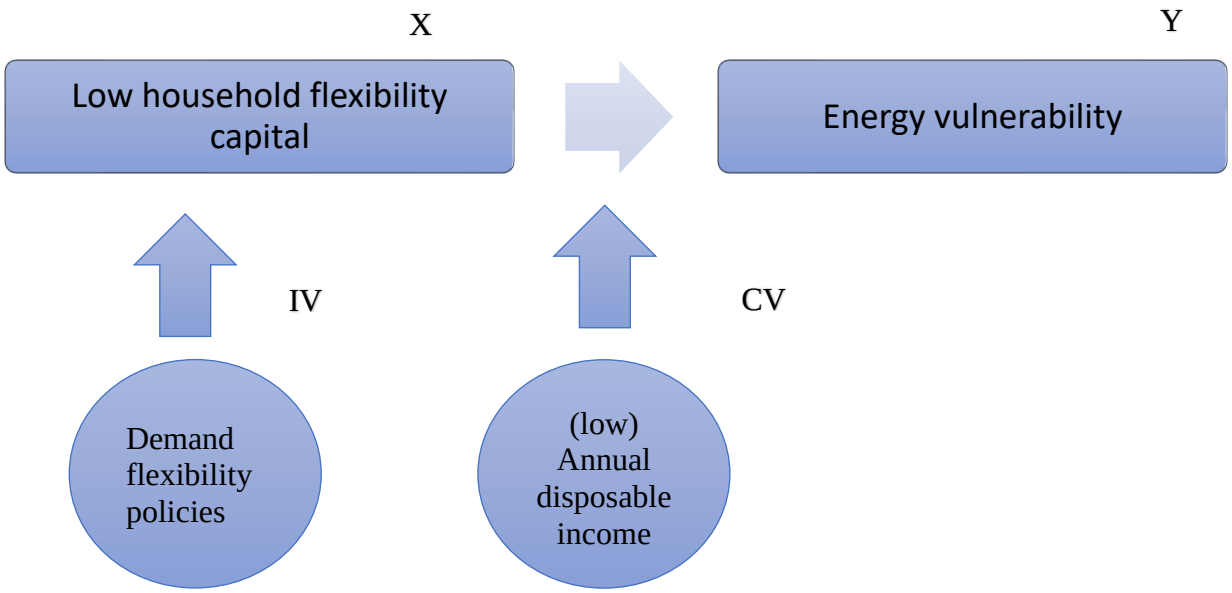
The overarching assumption of this study is that low household flexibility (X) result in energy vulnerability (Y) (see figure 1). These two variables are envisioned as the independent and dependent variable, respectively. This assumption was grounded in the previous theory and empirical observations (Platten 2022; Powells & Fell 2022). Although the assumption infers causality, it motivated the descriptive undertaking of this study, namely, how (multi-family) Swedish households experience their ability to provide flexibility (See research question 1).

As we have seen in the section 4.1-4.2, household flexibility and income have a clear interaction, and whether low flexibility results in a state of energy vulnerability or poverty is likely dependent on one's income. It follows, then, that this study additionally focuses on the role of income. This has been modelled in figure 2 where annual disposable income has been envisioned as a conditional variable (CV). Put differently, the relationship between X and Y is only expected to occur if households have a low annual disposable income. Naturally, it follows that a high enough income would limit this possibility. This conditionality has been descriptively framed in research question 2 namely, *"*accounting for income, to what extent do low flexibility within multifamily households lead to energy vulnerability?". Further concerning the interaction between X, Y and CV, it is assumed that households can supply the grid with flexibility, as in flexibility capital, either socially, or technologically (see section 4.1-4.2). The role of income becomes clear when we assume that the failure to economically equip one's household with energy efficient devices as in technological flexibility, would result in being penalized by the energy market. Whether low technological flexibility (X) results in energy vulnerability (Y) is therefore conditional on disposable income (CV). A similar logic applies to low social flexibility households which are understood as having habits that negatively affect their energy consumption. These households become economically penalized by the energy market due to their social practices and risk energy vulnerability. That is, unless the household's disposable income is high enough to mitigate the cost of being inflexible - hence its conditional effect.

Finally, research question 3 asks how households perceive demand flexibility initiatives. The assumption is that households with low flexibility capital hold negative perceptions towards flexibility policies. This negative perception is assumed to occur because households perceive such policies as intrusive due to the additional burden it imposes on one's lifestyle, either by exacerbating energy vulnerability by straining flexibility capital, or simply through inconvenience.

Figure 4. – An acrylic estimation model.

This figure depicts a series of variables where the cause (X) is expected to lead to the effect (Y). IV stands for instrumental variable, and CV stands for conditional variable which states that X only results in Y if a low annual disposable income is present.



5.5 Model limitations

5.5.1 Endogeneity

Endogeneity can arise when there is a reciprocal relationship between the independent and dependent variables. This means that the independent variable may be influenced by the dependent variable, which can make it difficult to establish a clear causal relationship. The issue of endogeneity affects much of social science research and should therefore be taken seriously.

While determining causality was not the focus of this study, it was necessary to supply a sense of confidence to the depicted acrylic model. Indeed, there may be reasons to suspect a reciprocal relationship in that energy vulnerability (Y) involves being in a state of low flexibility capital (X). In such a case, low flexibility capital cannot result in energy vulnerability as that would constitute a case of endogeneity. While this study does not claim to limit all sources of endogeneity, it can be limited by introducing control variables, specifying an instrumental variable, and by time ordering.

In this study, a conditional variable in disposable income was included to control for the effects of factors other than low flexibility capital that may also impact energy vulnerability.

Further, as seen in figure 1, I have specified the instrumental variable (IV) as demand flexibility policies which is the result of renewable integration. For the IV to be effective in limiting endogeneity and setting up a causal relationship, it should 1), correlate with the independent variable of interest, and 2), only affect the dependent variable through its impact on the independent variable. The premise of this study, as substantiated in the previous research section, is that demand flexibility policies (IV) may increase energy vulnerability (Y) by penalizing households with low flexibility capital (X). Consequently, the IV fulfil both conditions.

Lastly, time ordering refers to that the cause precedes the effect. This can be demonstrated with arguments pertaining to the IV and CV. It was argued above that energy vulnerability is expected to occur if households lack the flexibility capital to respond to external factors such as demand flexibility policies. This conveys that the cause, low flexibility capital, precedes the effect, energy vulnerability.

Further, I previously argued (section 5.4) that a high enough disposable income, as in CV, may reduce the costs of being inflexible and prevent energy vulnerability. This too, suggests that low flexibility precedes energy vulnerability.

5.6 Data analysis

The descriptive approach of this study was implemented with ease during the interview stage, whereby respondents' comments and thoughts were used as the basis for descriptive inferences (section 5.5). These answers were then categorized using a mapping scheme procedure that categorized relevant aspects of a phenomena (Esaiasson et al. 2017), such as flexibility or policy perceptions. The general idea was to bring order to find in-depth answers within, and between categories (Ibid). In that sense, the mapping scheme became an analytical tool to summarize the manifest thoughts of the respondents, while also leaving room for a latent analysis based on my own interpretation.

5.7 Operationalization

To make descriptive inferences (section 5.4), we must first transform abstract concepts into observable indicators. In this study, the central concepts of financial resources, flexibility capital, demand flexibility, agency, and energy vulnerability were previously defined and elaborated in theory chapter 4. Flexibility capital was previously defined as "the capacity to responsively change patterns of interaction with a system to support the operation of that system". Those patterns of interactions will be measured as *socially derived flexibility* and *technologically derived flexibility* (see chapter 2, section 2.2), which together entail the perceived ability to decrease or shift electricity-intensive activities.

Financial resources was operationalized as annual disposable income, and it was hypothesized to be a conditional variable. Annual disposable income involved three values based on a statistic provided by the Swedish statistical census bureau. These values are (in the thousands): 0-300, 300-500, and 500 or more. This study, however, focused on 300-500 and 500 or more since none of the interview respondents indicated an annual disposable income of 0-300.

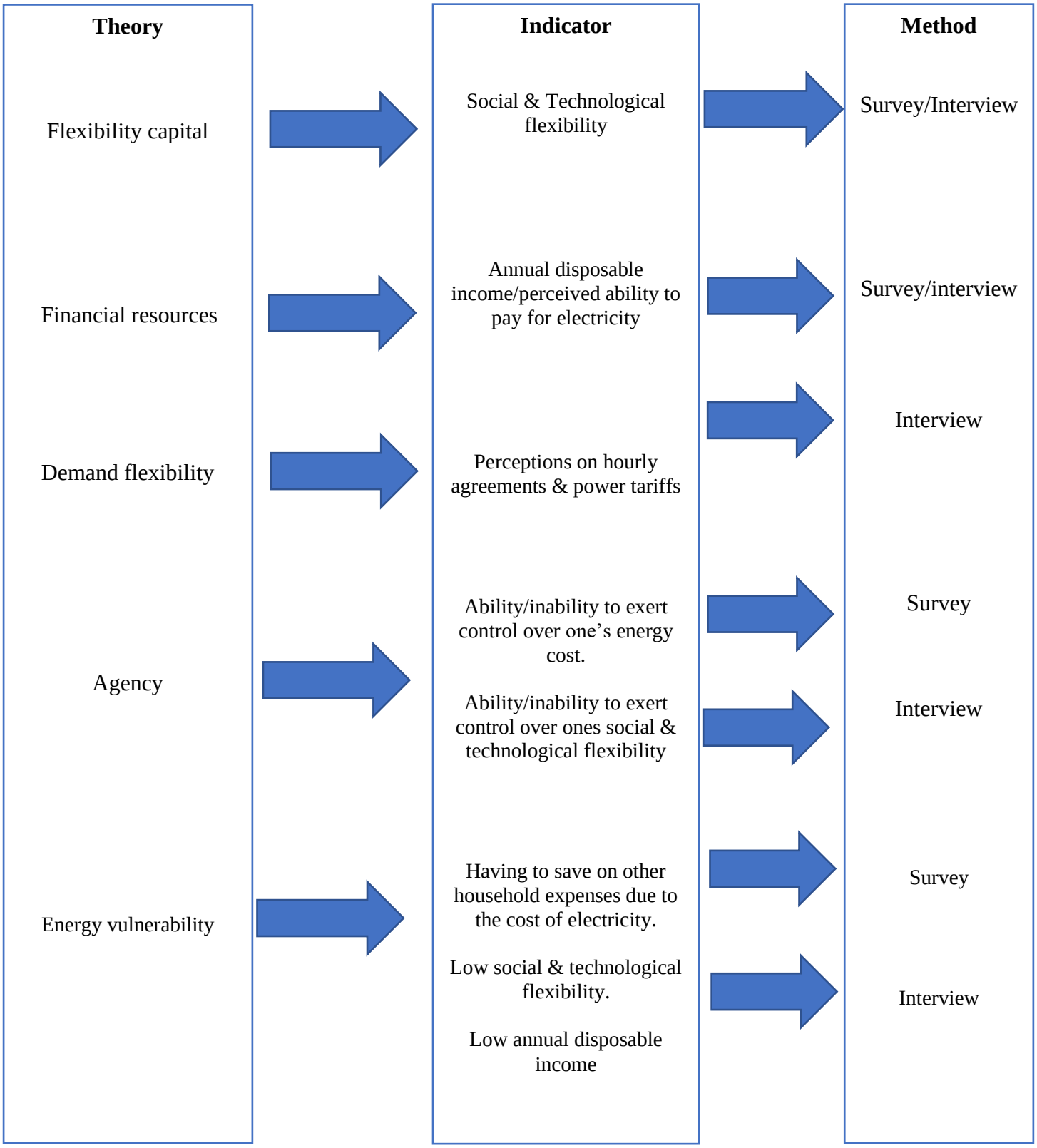
Additionally, for the interviews, it was conducive to add a second operationalization of financial resources to accurately capture the thoughts of the respondents. This indicator is *the perceived ability to pay for electricity*.

Agency is a concept that Powells & Fell argued may have energy justice consequences. It allows us to understand how households perceive their ability to exert and take control over their social or technological flexibility (Ibid).

Demand flexibility was previously defined as "a voluntary or involuntary change in electricity demand from the grid for shorter or longer periods as a result of a type of incentive". Those voluntary or involuntary changes in electricity demand can be controlled by policy incentives such as the *hourly agreements* and *power tariffs.*

Finally, *energy vulnerability* refers to a household's susceptibility to energy poverty through a dysfunctional interaction between flexibility capital and financial resources. It will therefore be measured as low social and technological flexibility and low annual disposable income, for the interviews. For the survey, however, it was operationalized as ´having to save on other household expenses due to the cost of electricity´. This indicator was included since it condenses the former indicator, making it easily understood by survey respondents.

Figure 5: Operationalization



5.3 Methodological limitations

One of the primary obstacles of this study was the difficulty in distributing surveys through housing associations and companies, as most actors were uncooperative except for Lunds kommun fastigheter. To circumvent this problem, the survey was distributed via social media forums, such as Facebook, which led to 50 responses from LKF and tenants. Nevertheless, there were significant difficulties in estimating the dropout rate, as it was challenging to gauge the number of users who received the survey due to the vast number of posts circulating on social media.

Another challenge was communicating the key concepts of the study to respondents during the semi-structured interviews. This was especially evident during the first interview where the technicalities surrounding the involved energy policies were perceived as difficult. For my second interview, then, I reconstructed the interview guide to make it more comprehensible to the respondents.

Another aspect that is worth nothing is that the study did not encompass households at the lower-end scale in terms of disposable income due to a lack of responses. Seeing that energy vulnerability is likely more pronounced within those income groups with the least financial resources, the exclusion of this group will no doubt affect the study and what I am able to claim about the results. Nevertheless, the annual median disposable income of multifamily households ranges between 220 to 530 (in the thousands)[12]. As such, by comparing income groups in the range of 300-500 and 500 and more, I am still able to draw significant conclusions.

5.3.1 External validity concerns

Lastly, I acknowledge the risk of not achieving theoretical saturation (Esaiasson et al. 2017) due to the small number of interview respondents. More interpretations and experiences of the concepts in this study are therefore likely to exist, which negatively affects my ambitions to generalize the interview findings (see section 5.2.3). Nevertheless, energy vulnerability and flexibility related experiences are still relatively understudied in Sweden, making it difficult to capture all potential experiences in a single study. Irrespective of these limitations, I have made attempts to limit the problem of theoretical saturation by including as many variables as possible (section 5.1)

5.3.2 Internal validity concerns

[12] This estimate has an extensive range since it depends on which household types (as in, multifamily household types) and living situations that is considered. Within this range, I have accounted for rental and owned apartments. The living situations include apartments where 1-2 people live together.

The issue of validity, which concerns the distance between theoretical definitions and empirical indicators, is a significant research problem (Esaiasson et al., 2017). In this study, there were some concepts used whose empirical translations may be questioned. For example, flexibility capital was translated into social and technological dimensions. However, the study only measured the perceived flexibility capital of households, rather than actual flexibility capital. I would argue, however, that the former became easier to operationalize since the latter would be a technical undertaking beyond the expertise of the social sciences. Earlier studies have also measured perceived flexibility capital – which descriptive studies well - so this approach is not unprecedented within the previous literature.

Energy vulnerability is another concept that was operationalized in this study, and Bouzarovski et al. (2017) notes that the concept involves a lack of energy efficiency, needs, access, practices, affordability, and flexibility. Due to time constraints, this study only measured financial resources and flexibility as indicators of energy vulnerability, while also taking practices into the account. This could be considered problematic since this study risks missing nuances of energy vulnerability. However, including all factors made little sense. Energy access, for example, is remarkably high in a country such as Sweden. And if access involves a household's access to energy efficient devices, then that was accounted for in the study through the operationalization of flexibility (technological flexibility). In the end, there is little doubt that energy vulnerability is a broad concept which involves a difficult operationalization. For that reason, I decided to rely on previous research which suggested that the interaction of financial resources and flexibility is the clearest indicator of energy vulnerability, at least in a country where needs and access to energy are generally satisfied.

A further concern with the study was the survey questions. Once distributed, it is difficult to amend mistakes or control the degree of misinterpretation from the respondents' perspective (Teorell and Svensson, 2007). Energy politics and related concepts are technical in nature, so the survey questions were carefully crafted to avoid systematic measurement of something other than what was intended. However, given the technical nature of the concepts, some degree of misinterpretation is possible. To address this, some survey questions were included in the interview questionnaire for clarification purposes (see appendix C).

6 Results &Analysis

Following a presentation of the survey and interview population, the result sections (6.2 & 6.5) will be presented as conclusions. These conclusions will then be substantiated by the empirical findings in the analysis subsections.

6.1 Survey population

Of the 50 respondents, a significant portion (66.7% and 26.6%) were situated in the SE4 and SE3 electricity areas, respectively, while a small number (6.7%) were unsure which electricity area they belonged to. Gender distribution among the respondents was almost equal, with 48% being men and 52% being women. The majority of the respondents, regardless of gender (64%), had received higher education of three years or more. A similar percentage (64%) were full-time employed, while a notable proportion (26%) were students. In terms of housing, more than half of the respondents (56%) lived in rental flats, 28% in condominiums, and 16% owned their apartments. The majority of households (54%) comprised of two adults, with 34% consisting of two adults and 8% and 4% consisting of three and four adults, respectively. A majority of the respondents (74%) indicated that no children were present in their households, while 18% had one child. When it came to electricity agreements, 64% of respondents had entered a variable agreement, 34% had a fixed agreement, and only 2% had an hourly agreement. A significant percentage of households (72%) had warm rent, which meant that the cost of heating and water was covered by the landlord. Surprisingly, a considerable number (24%) had cold rent, meaning that the tenant paid separately for heating and water. This is an uncommon practice within Swedish multifamily households and the survey responses should therefore not be seen as representative. Additionally, a substantial proportion (40%) of the respondents were unsure about how their homes were heated. Of those who were aware, district heating (32%) was the most common method, followed by water-driven electric heating (12%), direct current electric heating (6%), and heat pump/geothermal heating (8%). Only 2% of respondents used oil for heating, and none used biofuels.

6.2 Survey results

I presented three statements and three questions that the respondents were asked to take a stance on and answer, respectively. The statements were originally used by Platten (2022) to survey household flexibility in Sweden, and they answer **research question 1,** which pertains to household experiences on the provision of flexibility. The other three questions pertained to household knowledge, agency, and energy vulnerability, all of which were assumed factors affecting the provision of flexibility.

The results showed that the perceived flexibility capital among the respondents was relatively high at 70% for statement 1. When energy and climate benefits were communicated, this percentage increased slightly for statement 2, resulting in a large shift in the number of respondents who were in complete agreement. However, when asked to take a stance on statement 3, that is, whether or not respondents were able to absorb the additional costs by avoiding being flexible, there was a significant shift from "In complete agreement" to "I partially disagree.". This shift suggests that multifamily households may not have the resources to manage extra energy costs, or they may interpret such costs as coercive measures from external actors such as energy companies or public institutions, that interfere with their livelihoods. These results overlapped with research question 2 (the role of disposable income) & 3 (perceptions on policy) and were further explored in the interviews.

Further, it was important to not only ask the respondents to take a stance on their ability to provide flexibility, but also to what degree they experience their ability to influence their electricity costs. This constituted household agency, as in, the ability to exert control over one's situation, and it was numerically emphasized in figure 9. The results indicated a mixed ability, with most respondents having an average to below average agency.

The respondents' knowledge about electricity prices showed a relatively equal distribution among all answer categories, as shown in figure 10. Finally, the survey question on household affordability in relation to the cost of energy, which corresponds to energy vulnerability, indicated a low prevalence among the respondents. This survey question will be further explored in the interview section.

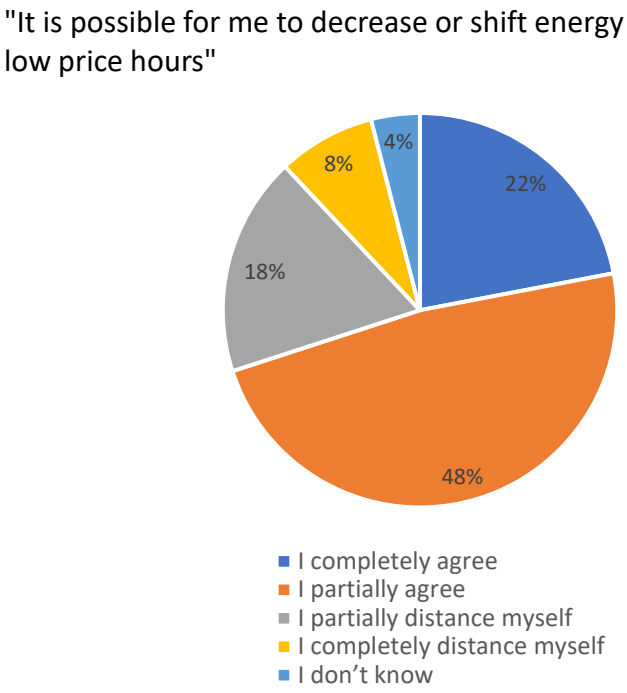
6.3 Research question 1

The following statements and questions pertain to research question 1: **"How do (multi-family) Swedish households within SE3-4 experience their ability to provide flexibility?"**

The statements were introduced with a text of my own making which stated:

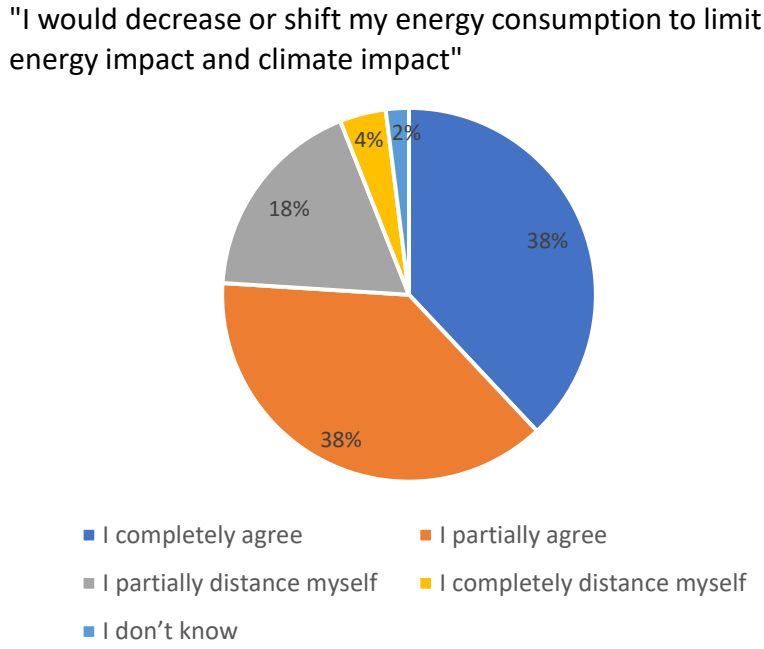
" What is your experience surrounding the following statements, considering your ability to decrease or shift energy intensive activities (such as using the laundry machine, doing the dishes, charging the electric vehicle etc.) to low price hours?"

Figure 6. Statement 1



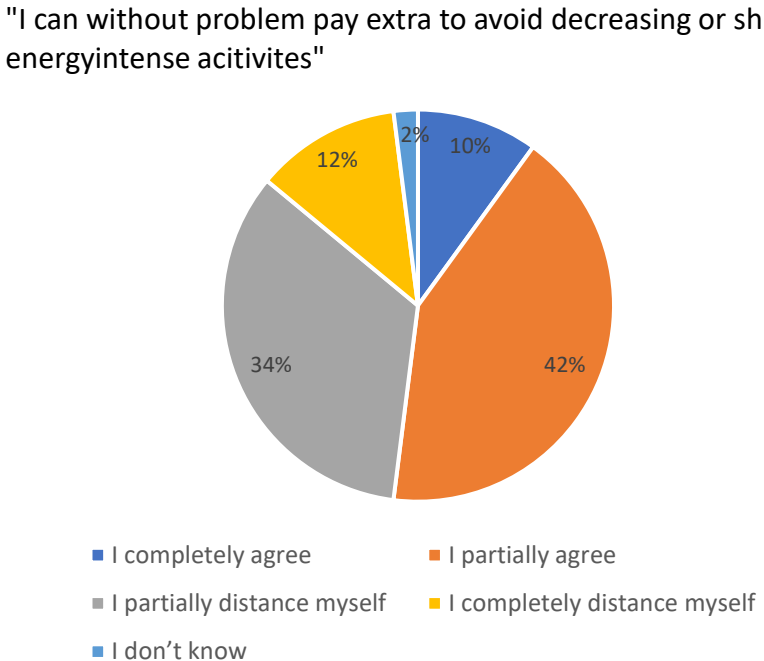
The results in the first figure showed that most of the respondents (70%) were positive to the provision of flexibility. Almost half of the respondents (48%) took the stance that they partially agreed to the provision of flexibility. This could be interpreted as the following: households recognize their existing flexibility capital as sufficient, but they are unsure to what degree action can be taken. 22% of the respondents completely agreed with the statement, was a similar amount to those that partially distanced themselves (18%), and only 4% indicated that they did not know if could decrease or shift energy consumption to low price hours.

Figure 7. Statement 2.



Statement 2 was included to see how household experiences concerning the provision of flexibility may change were the benefits communicated. As expected, households appeared positive to the provision of flexibility when energy and climate benefits were communicated. (38%) of the respondents were in complete agreement with the statement, while an equal amount was in partial agreement. Together, these positive stances were made up of 78% of the total respondents, which was an 8% increase compared to when energy and climate benefits were not communicated. 18% of the respondents partially distanced themselves which we see in statement one. There has been a 2% decrease from statement one to two.

Figure 8. Statement 3.

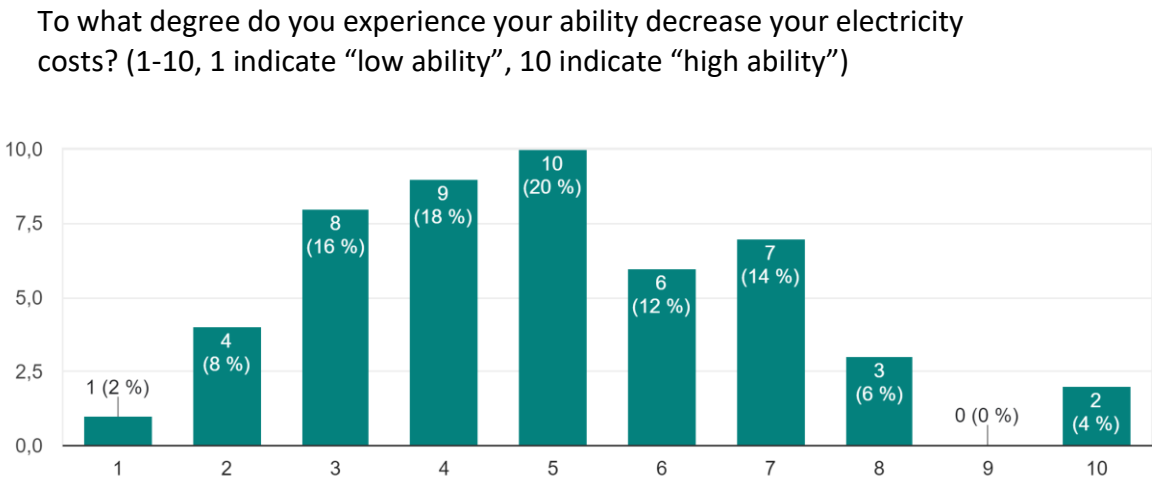


Statement 3 was based on the projected rollout of demand flexibility policies as renewables increase. These policies are expected to increase the cost of energy indirectly or directly at high demand hours to incentivize the provision of household flexibility to ensure a safe integration of renewables. As such, statement 3 gives us our first rudimentary look at the relationship between flexibility capital, disposable income, and the perception on energy policies (research question, 1-3).

There were significant changes when the respondents were asked to take a stance to statement 3. Only 10% of the respondents were now in full agreement that they would be able to suffer an extra cost to avoid the provision of flexibility. A near majority (42%) answered that they were in partial agreement, while a 34% of the respondents indicated that they partially distance themselves from the statement. Compared to the other statements, it appears that there was a large shift from "I completely agree" to "I partially distance myself".

6.3.1 Agency

Figure 9.



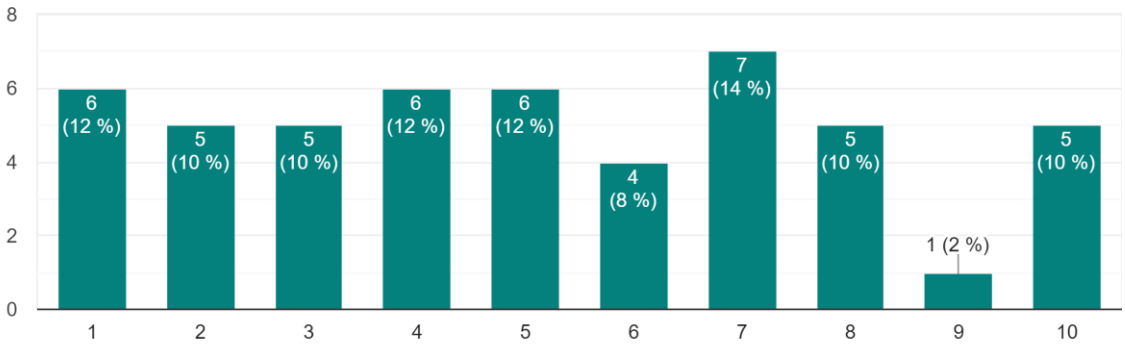
The numerical results of flexibility capital showed that the largest number (20%) of the respondents had an ability 5, which was right in the middle. 44% of the respondents were situated below the ability 5, and the remaining 36% were

above it. In essence, these results were rather equally distributed both below and above the ability 5. Going from the largest percentage groupings, most of the respondents (54%) were situated between 3 and 5, indicating that flexibility capital and agency was average (5) to below average (3). Finally, a minority experienced their ability as very low (2) or very high (4%).

6.3.2 Knowledge

Figure 10.

How good is your knowledge of when the electricity prices are high or low? (1-10, 1 = low knowledge, 10 = high knowledge

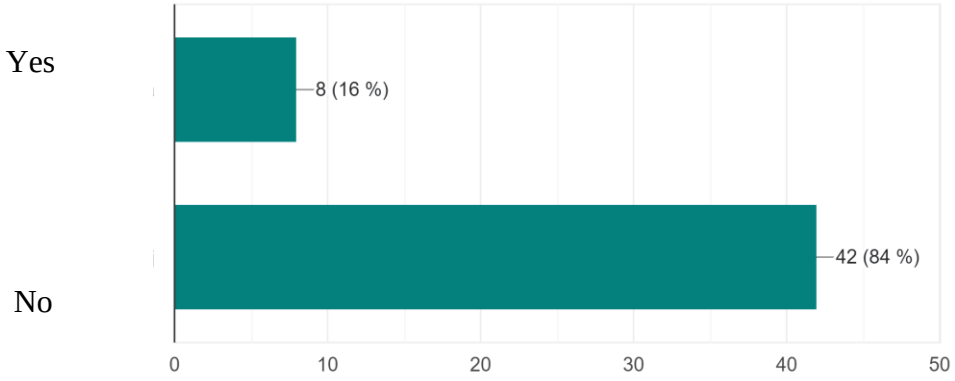


This survey question was relevant to get a sense of what household flexibility capital could be dependent on. Visually self-explanatory, these results were surprisingly equally distributed along the answer categories. The only outlier was answer category nine, which had 2%. The equally distributed answers could indicate a sense of uncertainty among the respondents, that is, a partial overestimation of one's knowledge, or an underestimation. More respondents would have to be gathered to know for certain.

6.3.3 Energy vulnerability

Figure 11.

Have you had to save on other household expenses to manage electricity consumption?



Lastly, I included a survey variable to indicate rudimentary evidence of energy vulnerability. This corresponds to research question 2 “Why do low flexibility capital lead to energy vulnerability”. That said, the explanatory ambitions of this study concerning research question 2 were limited to the interview section.

The results showed that a majority of the households (84%) did not have to save on other expenses to deal with their electricity consumption. This indicates that energy vulnerability has a low prevalence since their energy expenses do not conflict with their overall affordability. That said, to a larger number of respondents would be needed to determine if this majority persists.

6.4 Interview population

The interviews ranged between 20-40 minutes and were proven fruitful to the analysis. The respondents were selected based on 11 out of 22 theoretical and general variables where all variables except income were held constant. (See appendix D). The respondents which have been anonymized under pseudonyms, were all employed and consisted of 5 persons from income group A and 4 from group B. Despite belonging to different income groups, they pre-indicated in the survey that they had not had to been frugal with other household expenditures because of the energy crisis. Four respondents were men and four were female. lived in small apartments and 3 of the respondents had cohabitation. All the respondents experienced warm rent as opposed to cold rent (see section 5.3.2 or appendix D), and they had all entered into variable electricity agreements. Two of the respondents resided in electricity area 3, while the rest belonged to electricity area 4.

6.5 Interview results

The findings concerning flexibility related experiences (research question 1) were condensed to three themes (see figure 12). These were 1) ´What I do´, 2) ´What I could do´, and 3), ´Beyond my control´. Within these themes, it was found that the interviewees only relied on social rather than technological flexibility. For example, the interviewees noted that as long as their current financial situation was stable, they would rather keep the status-quo than investing in devices that could

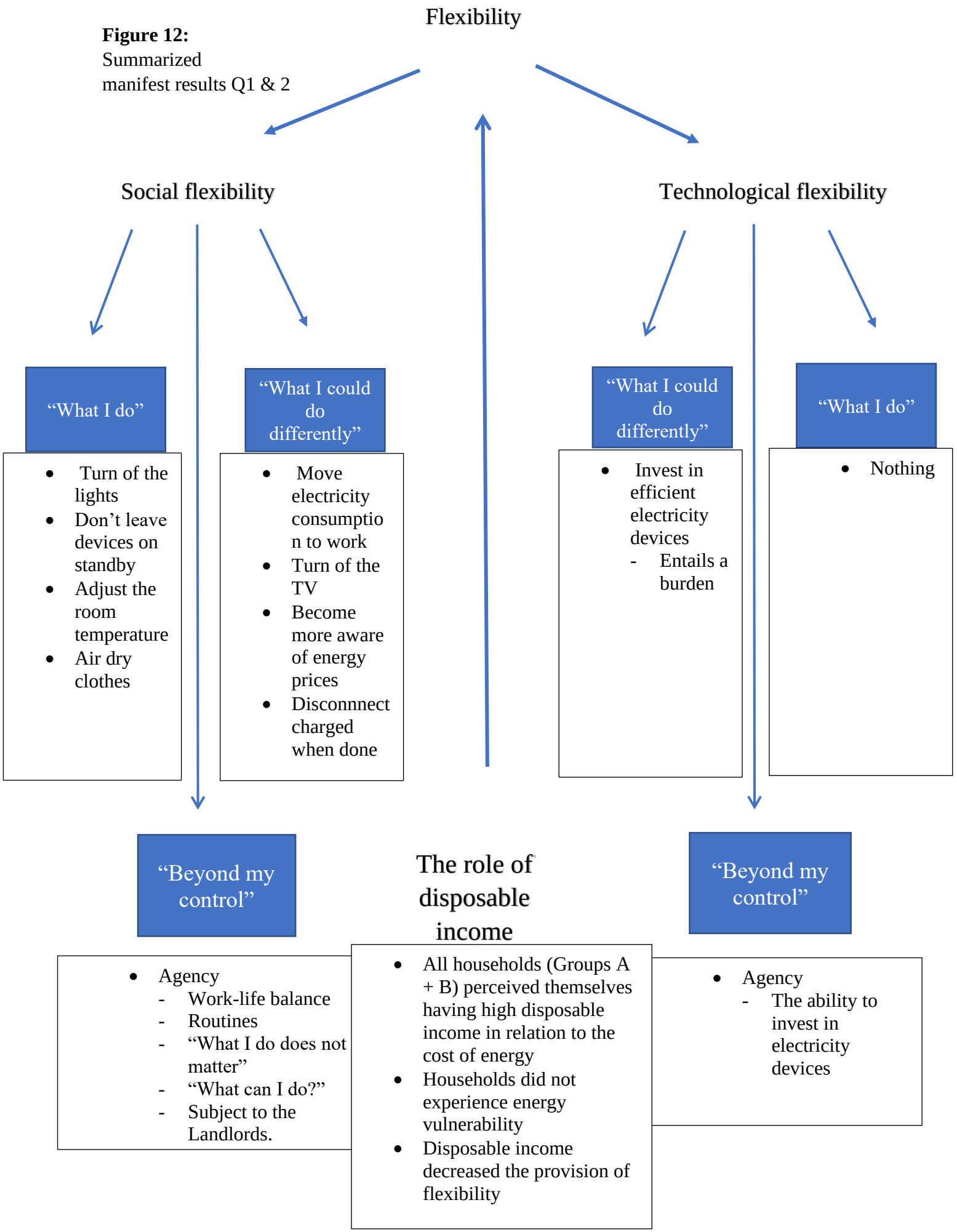
bring down the cost of energy (section 6.6.1). This sense of awareness had a bearing on the provision of social flexibility as well since it affected their willingness to adopt frugal social practices. Nevertheless, social flexibility, although low, was the primary provision of flexibility capital. The reason the overall low flexibility capital was found in the latent analysis which looked to bridge the themes to discern more in-depth answers. As it turned out, both social and technological flexibility was dependent on three factors. These were: 1) Knowledge, The cost of electricity in relation to one's income, 3) and Agency. Taken together, it was found that the interviewees had low flexibility capital largely due to a lack of knowledge on the electricity market, a lack of agency due to their relationship with their landlord, and due to perceiving the cost of electricity to be low relative to the household's disposable income.

To answer research question 2, there was a need to control for disposable income. It was found that disposable income was experienced as having a significant role in mitigating the penalties of being inflexible within both income groups. Indeed, a recurring theme among the interviewees was the perceived relationship between disposable income and the cost of electricity. The analysis found that all households perceived the cost of electricity to be low in relation to their income. As a result, energy vulnerability was experienced as absent throughout the households despite relatively low flexibility capital. While the different income groups had slightly different experiences concerning energy vulnerability, there were no clear differences between the two compared income group.

The third question that this study sought to answer was; "How do households perceive demand flexibility policy initiatives?". Power tariffs were largely viewed as unfair and ineffective. When the respondents were given the opportunity to reflect on why they felt that way, a common belief emerged which pointed to the burden that it would impose on households with daily work routines, as well as the unfair double burden that it would entail. However, some households perceived power tariffs as a steppingstone towards ´a greater good´ in the sense that it would benefit society in general, and the grid in particular. These views were accompanied with a high trust in government. The results were ultimately polarizing and leanting towards negative views. on this proposal manifested as mixed, and often strong emotions in terms of reactions, language use, and the appeal to fairness.

The views on hourly agreements were less polarizing, but nevertheless just as mixed. Although hourly agreements were also viewed as intrusive, they were perceived as voluntary and not, unlike the power tariffs, as a top-down approach enforced by some distant politician.

Figure 12:
Summarized manifest results Q1 & 2



6.6 Research question 1

“How do (multi-family) Swedish households within SE3-4 experience their ability to provide flexibility?”

6.6.1 “What I do”

Experiences concerning technological flexibility showed that households would not invest in energy efficient devices. These devices, which in theory could decrease electricity consumption at peak price hours, were often “not prioritized” (Magnus, Joakim, Helena) or “worth the effort” (Kalle, Ingrid, Bengt). Instead, it was revealed that they would often engage in various electricity saving activities through social practices, known as social flexibility. For example, Johanna who lived in a flat with her brother said that: “..The only thing that came to mind was to turn off the devices that I have”. These devices included limiting vacuuming (Lina), “turning off the lights” or “not having devices on standby” (Johanna, Lina). This was a common trend among all respondents, and the only outlier was a respondent that sometimes air dried her clothes as opposed to starting the machine dryer (Helena).

6.6.2 “What I could do differently”

Further, when the respondents reflected on what they could do differently in the future, they mentioned actions such as turning of the tv or disconnecting the charger when it was done. Magnus mentioned investing in smart technology, which is usually connected to smart metering, that is, a system that measures energy consumption in real time (see section 2.2-2.3) and effectively creates the conditions for technological flexibility.

> *“So I could absolutely imagine having remote control. It would have been as nice as well. But uh, yeah. Nothing that's urgent right now so I don't think it's something we're going to be pushing. But if we had a house... then it would have been a completely different matter of priority.”*

However, acquiring smart technology was not urgent in the sense that the current cost of energy demanded it. In that sense, Magnus unwillingness to invest in smart technology was one out of convenience. Indeed, from a practical standpoint, these technologies have previously been linked to an increased perceived sense of burden among households (Korsnes and Throndsen 2021).

Underlying comments such as these among all respondents was a sense of non-urgency. A common theme that emerged was that the situation would be worse had they lived in a single-family household, which would, in essence, drastically change what they would be willing to do differently.

6.6.3 The role of knowledge

Having said that, electricity saving activities are not necessarily the same thing as supplying flexibility to the grid, though. While every energy saving activity counts, the so far mentioned devices were neither energy intense, nor were they consistently decreased or shifted to hours of low cost. Ultimately, a central theme of all the households was that they did not decrease their electricity intense activities, nor did they shift consumption to hours of low demand. Indeed, the respondents were often unaware that hours of low cost, and thus a period of low electricity demand existed in the first place. Johanna noted that she could have done things differently had she had the knowledge:

> *"..I was not aware that there were was hours where the electricity maybe was cheaper. And I realize that if I knew that if you put on the laundry machine at 11 pm, and if it were cheaper, I might have chosen that."*

Knowledge, or awareness if you will, in the case of Johanna, seemed to be an enabler of flexibility, and the lack of knowledge on the topic was perceived as a major barrier for these households to supply flexibility to the grid. However, even when the concept of hourly costs had been heard of, the perceived impact of the cost of electricity in relation to the household income was too low to motivate action. In other cases, knowledge did not have a bearing on the provision of flexibility. Magnus who lived together with his partner indicated in the pre-distributed survey that he had a remarkably high awareness of when the electricity prices were high or low. In fact, he was the only one out of fifty survey respondents who indicated a 10 on a scale from 1-10 (1 being not aware, and 10 being very aware). Despite this, he stated that "We don´t check what the electricity prices are every hour, we don't check it at all. We just carry on as usual. But it has only been a maximum of a thousand krona per month". These findings point to the role of disposable in relation to the cost of energy and will be further explored in subsection 6.7.1 "The role of disposable income".

6.6.4 "Beyond my control"

The last shared experience among the households was a lack of agency which manifested in diverse ways. I call this external and internal agency. To illustrate the difference, Joakim, for example, who lived in a small apartment with his dog said:

> *"Yes, I don't, I don't have my own dishwasher, washing machine, I mean, the fridge draws a lot, but I can't influence that. Then I have to cook. Then my computer, yes I have to work as well. I can choose to maybe go to work more often to work if I want to save electricity, but I don't think it will mean huge savings. I can certainly reduce it (electricity consumption) by five to ten percent if I really try. But I think I'm pretty thrifty as it is."*

And Helena, another tenant in a small apartment noted that:

> *I was contacted by HSB two or three months ago; they asked me to make an inventory on white goods I had in my apartment. And then I did it because then they would decide whether I needed, whether they would upgrade my appliances to more energy-efficient appliances. I did that inventory but haven't heard from HSB yet. So, I guess I have enough energy-efficient appliances, at least in HSB's sense*

Both Joakim and Helenas reflections were similar to that of other households whom indicated that electricity consumption was beyond their control, albeit in different ways. Joakims loss of agency was internal and had both social and technological dimensions. For example, Joakim felt limited in what he could do in terms of behaviour changes, indicating a low social agency. However, his technological agency was high due to having enough disposable income to invest in energy efficient devices and appliances.

Helenas's loss of agency was external in the sense that she found herself incapable of making her household energy efficient. Indeed, unlike single-famliy households, who are typically their own landlords, multifamily households are limited in what they can and cannot change. They are, in essence, reliant on their landlords or housing associations to make investments pertaining the household insulation, the installation of solar cells, etc. This external loss of agency could be understood further by exploring the household-landlord relationship. In regards to the relationship with his landlord, Johannes said that: "it practically does not exist" because "we rarely come in contact with our landlord excpect for when they decide..". A shared experience among the households was that the relationship between tenant and landlord was "impersonal" (All respondents). Indeed, if push came to shove, the majority of the households believed that the landlords would not be particularly responsive to any energy related request. This dependency and external agency problem is noted by (Powells and Fell 2019) as well. That said, the inability to leverage energy related investments through the landlord are not necessarily a problem since many Swedish multifamily households are relatively energy efficient. While it is certainly true that Swedens older housing stock need energy efficient investments, the newer housing stocks are often efficient, and most multifamily households generate their heat from district heating, as opposed to electricity, making them less vulnerable to energy efficiency related concerns.

Lastly, the feeling of a limited social agency could also be attributed to the respondents own social practices. In response to whether Magnus was able to provide flexibility, he said that:

> *".. I also mainly think about the fact that we are not at home. It may be that electricity prices are even lower when we are at work and not at home at all. And then maybe the electricity price will go back to the original when we are back home, so that is what I'm thinking about, that it will be a little more difficult to control that..."*

In this case, Magnus´s made correct remarks on the supply and demand trend for electricity. A typical household have tenants with 8-hour job, be it school or

something else. This poses problems for households since electricity prices are generally high during breakfast or dinner hours. As such, the households found it difficult and sometimes unfair, to navigate their daily practices to provide flexibility to the benefit of themselves and the grid.

6.7 Research question 2

“Accounting for annual disposable income, to what extent do low flexibility within multifamily households lead to energy vulnerability? “

6.7.1 The role of disposable income & energy vulnerability

A recurring theme among the interview findings was the relationship between disposable income and the perceived cost of electricity. The latent analysis revealed that all households perceived the cost of electricity to be low in relation to their income. As a result, energy vulnerability was absent throughout the households.

Lina who belonged to the higher income group B said that the cost of her energy bills corresponded to about “250 krona a month”. This a relatively low sum, which indicate that she does not consume much electricity, regardless of its cost. Indeed, she had not “…even noticed if it has increased, and therefore “..thought about it”(Lina). It became clear that Linas’s knowledge on flexibility in combination with her will to engage in it through social practices were dependent on how high her electricity bill had been in relation to her disposable income. Whenever Lina, nevertheless, decided to shift her electricity consumption, for example, by vacuuming at different hours, it was without regards to the specific hours of low demand. Overall, Lina displayed a relaxed position towards the cost of energy. She would often underscore that her energy bills did not involve a large household expense. At the same time, though, she noted that:” I have worked politically in the social welfare committee, I know that fifty kroner matters to some people. But it's just hard for me to feel, to imagine the difference between fifty krona”. Linas’s reflections where not only indicative of an ability to sympathize by putting herself in the position of another less financially secure person, they also demonstrated a sense of self-awareness. Indeed, her overall reflections implied that the dominant reason behind why she did not perceive the cost of energy particular high was because of her disposable income.

Magnus who belonged to income group B stated that: “We have two people with a good income and no electric heating. It actually reduces the impact quite a lot. So, it's good.”. Just like in the case of Lina, these passages from Magnus indicated a certain degree of knowledge on the topic. Magnus said that he knew where the electricity market prices could be found (the website), but despite this, he did not apply his knowledge. Similarly to Lina, there were little indications that Magnus found himself incentivized to provide flexibility by acting on his

knowledge. This is likely attributed to the perceived impact of the cost of energy. To further illustrate this relationship as an enabler of flexibility. Ylva, who also belonged to income group B, mentioned that: “I live in apartment so it's not going to be as ridiculous as if you live in villa for example I mean if I live in villa, the cost is going to be fifteen thousand and will be a different story”. This reflection was echoed by several respondents who perceived their position as being privileged. The households imagined a ´what if´scenario, as in, what if they lived in a single-family which would be bad, as opposed to a multifamily household. At the same time, because of this perceived privileged position, the households were rarely inclined to sacrifice comfort or convenience in order to provide flexibility.

Indeed, making remarks on his comfort, Kalle, who belonged to the lower income group A, said that: “I don't really mind let's say paying a couple 100 (krona) more as long as I got comfortable, I would say. And of course, like also decrease cost for some other stuff.”. Several of the respondents within low income group made similar remarks, indicating that that they would rather take the extra rather electricity cost than sacrificing comfort. Their comments indicated that disposable income was not an issue, despite the rising costs of electricity (Ingrid, Helena, Bengt, Johanna)

Looking at the role of disposable income specifically, the findings indicated no significant differences between the two compared income groups A and B (see section 5.4) .Groups A and B were both unwilling to engage in flexibility practices either due to a lack of knowledge, or since it would interfere with their comfort and convenience. Johanna who belonged to the lower income group, namely group A, however, shared thoughts which deviated.

“Hmm. No I don´t think so. The only thing that comes to my mind is what if I would have had a higher income then I would probably had more things that consume energy in my household”

“One example is something that I have wanted to have for a while, namely, a rice cooker. I can feel that it is a bit inconvenient to cook rice in a pot. And had I had such an income that I would not be concerned with my purchases then I would have bought more things. You know, like some unnecessary stuff that I would probably been able to do without..”

Reflecting on the role of income within her household (in relation to the cost of energy), she said that she would likely purchase new devices to make her life more convenient. The above passages indicate a rebound effect, which can be understood as the reduction in expected gains from modern technology, such as household devices or appliances. Put simply, by investing in presumably efficient devices to off-set the cost of energy (increased energy efficiency), Johanna would see a reduction in expected efficiency since her income allowed her to buy more devices in the first place. It is unclear whether a higher income would increase her total household energy consumption, however, it is a probable scenario.

Following this, it can be deduced that socially derived flexibility such a social practice which involves cooking meals at low demand/price hours could be

assumed to be more important than technological flexibility. Since technological flexibility is dependent on income, households with higher technological flexibility may risk consuming more energy in the long-run in multifamily households and off-set the saved energy costs by having more efficient devices. Having said that and holding all other factors equal, the risk of experiencing rebound-effects is likely lower in single-family households where ones is allowed to install solar panels on the roof. These solar panels could generate one's own electricity find themselves decreasing their energy consumption despite having a higher disposable income.

6.8 Research question 3

"How do households perceive demand flexibility policy initiatives?

6.8.1 Power tariffs

Concerning power tariffs, Magnus said that:

> *"So spontaneously, and it may be that I don't understand it, but spontaneously it feels quite absurd. They (households) pay quite a lot, especially if you live in a house. Er, they already pay a lot in taxes, and they already pay a lot for electricity. So I don't understand why you would want to tax people on electricity when it is absolutely the most expensive. Yes, it feels a bit uncertain to me spontaneously".*

Magnus, like the other households, implied that households were already facing the consequences of the ongoing energy crisis and should not be taxed any further. With the use of strong language, it became clear that the power tariffs in this case were not well received, not only due to the ongoing energy crisis, but also because taxes in Sweden were already experienced as high. This sentiment was echoed by Bengt, who felt like "we already pay a lot of taxes in the 1st", and that "you just have to apparently accept it".

While not as negatively outspoken as Magnus, Bengt showed signs of resignation while noting, just like Magnus, that the taxes were already high. Bengt thoughts and behaviour during this phase of the interview mirrored the perceived lack of agency that was previously noted in section 6.2.4 ("beyond my control").

While the power tariff was largely perceived as an excessive burden for households that were already struggling with their livelihoods, though. Johanna, for example noted a different aspect:

"..I am not really happy about that (power tariffs). But I feel like what you could do as a consumer is to cook at different times. But at the same time there is a reason everyone cook food at that time, that is because you must go to the job and after

that when you come home you get hungry. After you have had a training session then you are hungry. Should I then wait two hours to cook to avoid the tax? That does not feel so good"

Johanna perceived herself as being locked into practices – such as going to work. Moreover, she implied that few households could influence when they go to work or come home given the typical 8 hour working routines of a typical Sweden. In that sense, for Johanna, the power tariff came of as major disruptor of private life, but more than that, the policy was understood as a form of punishment. Although not explicitly clear, Johanna stated that "..there is a reason why everyone cook food at that time…" , implying that she was just living a normal life. With this reasoning, why would Johanna, or anyone else for that matter, pay extra for living a ´normal 'life? In that sense, the power tariff came off as "unfair". Similarly, Joakim implied that the policy may have a punishing effect: "But if people can't change (their behaviours or social practices) then, then it's not very helpful.". On the flip side, Helena said that:

" Um yes. It's this 'covid flatten the curve feeling'. Yes, but my first feeling is that it is reasonable, but I haven't thought through that insight more than that. It is of course, well, the electricity grid, yes there must be balance in the electricity grid and if a lot of people use it at the same time as we do not cover with enough electricity production, then it is the case that, you tax to encourage a certain behavior. And if you think, if you give taxation then more people can move from using electricity during peak hours to, yes but when we have low hours for example.."

Helena made an analogy to flattening the curve, referring to how the governments and state agencies around the world had to take draconic measures to guarantee societal stability following the covid-19 pandemic. Her analogy implied a high trust in policymakers and in that sense, she found the power tariff to be a justified, fair measure to produce "balance in the electricity grid", despite the personal costs that it may impose.

6.8.2 Hourly agreements

The stark contrast between hostility and encouragement towards power tariffs were replaced with a mix of cautious scepticism and cautious optimism when hourly agreements came into question. Magnus comments were found representative for the respondents that had in-depth knowledge:

"The downside is that you need to be active, and not many people are happy about that. But apart from that, it feels clean, cost-wise, so I just think it will be good. Because then you can control it yourself. Then I think

that some people can't, so if you don't have something like that, there are many automated functions you can turn off electricity with a phone and shit remotely. Eh, and maybe not everyone has access to it. And then it might be more difficult for those who can't steer, etc. So the disadvantage is that you need perhaps some form of remote control."

Magnus comments pinpointed a central characteristic of the hourly agreements. They are, in essence, seen as positive if the household have the capability to align it with their social practices and technology, and negative if that is not the case. As it turns out, several respondents were inclined to mention this characteristic in one way or another (Joakim, Magnus, Ylva, Kalle). What was particularly interesting with Magnus comments though was that they revealed an investment and digitalization barrier. It is safe to assume that households can only benefit from hourly agreements if they are knowledgeable in digitalization matters and have the capability to invest in smart technologies. Adapting energy consumption to specific hours through active participation, as Magnus notes, was therefore experienced as an unnecessary burden.

To further illustrate the issue with hourly agreements, Ingrid said that: "I mean, I think it's, it's worked for some people if they're really discipline and I'm not disciplined person, I would say hmm.". She gave examples saying that she would prefer to note start the dishwater at midnight because it was cheaper. There was simply little incentive to "make life harder than it is (Ingrid). Ingrid furthered the above-mentioned reasoning but was more focused on social practices than on the challenge of aligning practices with technology. Her thoughts echoed the issue addressed in subsection 6.2.4 ("beyond my control"), that social practices or daily routines were ´locked in´ , and any outside interference would be experienced as a burden. Although Ingrid did not perceive hourly agreements as impossible to integrate with daily life, hence the emphasis on it being a problem of "discipline", it was, nevertheless, perceived as something that would sacrifice quality of life. This detriment to the ´quality of life´ was a sentiment shared by several respondents. Helena, who although praised the hourly agreement because it could "benefit electricity consumers in the long run", noted stress that it could induce in daily life. It involved allocating energy throughout the day to "keep track of the electricity prices" and was therefore perceived as a cognitive effort.

7 Discussion

7.1 Results discussion summarized

The first research question which explored experiences on household flexibility showed conflicting results. While the survey indicated a high to mediocre flexibility capital among multifamily households, the interview findings suggested that participants were often more limited than they realized, indicating a below mediocre flexibility capital level. The interview results point to an overestimation among the households concerning the provision of flexibility. For example, while the interviews showed that households certainly could adapt their electricity consumption, it rarely included energy intense activities. The latent analysis of the manifest thoughts of the households revealed that energy intense activities were often limited by three factors: 1) *Knowledge* 2) *Agency* and 3) *The perceived impact of the cost of energy in relation to one's disposable income.*

For **the second research question** it was assumed that low flexibility capital resulting in energy vulnerability, was conditional on annual disposable income. The manifest results showed that disposable income was experienced as having a significant role in mitigating the costs of being inflexible. Households would often mitigate the costs that the above-mentioned barriers imposed on their lack of social and technological flexibility. As a result, the extent of energy vulnerability within the households was seemingly low. Surprisingly, this was true for both income groups A and B.

Finally, **the third question** which focused on how households perceived demand flexibility policies showed mixed to negative results throughout the interviews. Similar findings were seen in the distributed survey where there was a significant shift from "In complete agreement" to "I partially disagree.", in regard to whether or not households could manage extra electricity costs.

7.2 Results discussion in depth

When considering the lack of **knowledge** among households regarding smart energy systems, it is often attributed to limited education or interest. However, the households in this study showed a relatively high interest and engagement during

the interview stage, which suggests a different explanation. As Strengers (2014) points out, smart energy systems appear to be designed for "resource man," an energy consumer who already possesses knowledge and interest in energy use, and who has the economic or practical ability to shift consumption away from peak hours. Platten (2022) notes that this design and understanding of households as rational economic beings within the energy systems tend to dominate, which may present a barrier to a significant part of the population whose primary concerns are rooted in the need to perform energy-demanding activities in daily routines (Fjellså et al., 2021b). Policymakers may therefore need to emphasize designing for justice in energy systems (Milchram et al., 2020) to address this issue.

Household **agency**, or the ability to exert control over one's flexibility, is a crucial factor in determining energy justice, as emphasized by Powells and Fell (2019). They posit that agency can be controlled by oneself or by external actors. The results of this study showed that internal agency within multifamily households was low, while external agency – concerning technological flexibility – was primarily controlled by the landlords. Indeed, as it turned out, larger scale energy efficiency investments were exclusively dependent on the willingness of the landlord, and at times, the relationship between the households and landlord.

Further, the **perceived ratio between income and electricity costs** had a significant impact on whether households chose to increase their flexibility capital or not. Although the disposable income among both income groups acted as a buffer to mitigate the costs of being inflexible, it also showed discouraging effects on the willingness to adapt frugal energy practices. The results indicate that a sufficient income in relation to the cost of energy prevents energy vulnerability, but paradoxically also contributes to it by lowering flexibility capital.

One reason behind the relatively low impact of electricity costs can be attributed to the housing stock. In Sweden, multifamily households are relatively efficient, and predominantly heated through district heating, rather than electricity. This entails the concept of “warm rent” where tenants do not pay for the cost of heating. Indeed, this has seemingly resulted in low electricity costs even for households with low flexibility. In the end, this explains why Swedish multifamily households depend on their **annual disposable income**, rather than on their flexibility capital, and by extension experience a low extent of **energy vulnerability**. Additionally, the concept of warm rent explains why the two income groups in this study showed minimal differences in terms of the extent to which they were exposed to energy vulnerability. Having said that, this study focused on two income groups representing an average to high income group. Group A had an annual disposable income of 300-500 (thousand) krona, and group B had 500 or more. It is possible that the income groups at the lower end scale of 0-300 would exhibit different results.

Regarding perceptions on policy, it was immediately noticeable, partly through the distributed survey results, and partly from the interviewees, that the respondents did not want to enter hourly agreements, despite perceiving it positively. This is reflected in Sweden at large, where the amount of hourly agreement users is low. One explanation for this is a lack of knowledge on what such an agreement entails in practice. Another, more likely explanation is that households refrain from

entering hourly agreements as it would challenge their flexibility. Hourly agreements require effort to decrease energy consumption or shift it to hours when electricity prices are low, which could risk situations where households, due to poor energy consumption habits or an inability to invest in energy-efficient technology, end up with large energy expenses. This is simply not convenient, so households tend to enter fixed or variable electricity agreements instead.

Ultimately, the way that the interviewed households perceived **power tariffs** and **hourly agreements** were two sides of the same coin that aligned with the research on policy acceptability. Faure et al. (2022) for example, researched household acceptability of energy efficiency policies across the European Union. By presenting the respondents with three policy alternatives, they found that policies were less likely to be accepted if they were coercive, associated with personal costs, and perceived as ineffective. Their findings on policy acceptability were partially reflected in this study. Hourly agreements, for example, which had been around since 2012, had a mixed response. While some households appreciated the additional flexibility and responsiveness that it entailed in relation to the energy markets, others saw it is as a measure that would entail induce stress and more inconvenience. In either case, the households refrained from becoming too emotionally invested in the policy since it was perceived as a voluntary measure. Power tariffs, on the other hand, were perceived as strictly coercive and as an interference in daily life. A standout response was that it directly interfered with existing social practices, and that it was ineffective and associated with personal costs.

7.3 Conclusion & practical implications

The study's finding indicates that Swedish multifamily households display a discrepancy in terms of their perceived ability to provide flexibility. While the survey results indicate a relatively high perceived flexibility, the interview results reveal that in practice, its provision is heavily dependent on and limited by a lack of knowledge, agency, and the perceived ratio between disposable income and the cost of electricity. When interviewed, it was shown that the respondents often overestimated, and sometimes misunderstood what flexibility provision entailed. This may have implications for both the energy grid and the households themselves, as the ongoing energy transition is expected to increase the need for system flexibility. Policymakers may need to take these enablers and barriers into account to decide which policies will be most effective. One potential solution is to introduce long-term information campaigns to improve energy system knowledge, either locally or nationally. Strengthening tenant energy investment capabilities, such as providing economic subsidies, or involving and engaging tenants in third-party organizations such as Hyresrättsföreningen may also help to increase household agency.

Despite the fact that these factors are often seen as barriers, it is difficult to argue that Swedish multifamily households are energy vulnerable in a strict sense. The

findings show that while the energy crisis has prompted behavioural changes and new energy consumption practices among multifamily households, they do not perceive their situation as one of energy vulnerability. This is largely due to the households' financial resources, particularly the annual median disposable income, which is relatively high within the two compared income groups and enough to offset the costs of inflexibility. However, as Sweden continues its energy transition, it is possible that energy vulnerability will become more prominent as the mitigating effects of disposable income decreases within multifamily households. This may particularly be the case for income groups at the lower end which were not accounted for in this study.

Moving forward, policymakers need to not only consider the impact of flexibility policies but also their acceptability, which were shown to be largely negative. While such policies may serve a broader societal goal of enabling the energy transition, it may amplify conflict. Indeed, low levels of policy acceptability among households can delegitimize public institutions, potentially resulting in an incohesive democratic process. This is, in many ways, a classic problem of efficiency versus legitimacy which will be crucial to examine – along with the social implications of energy policies - as the energy transition continues to reshape the energy sector.

7.4 Generalizability & Future research

While there is a need for more interviews, the conditions to generalize this study's findings were relatively good. For one, multifamily households, which is a common housing form in Sweden were the central unit of analysis. Multifamliy households are also a common housing form in many urban and suburban communities across the globe. The issue with generalizing the findings in Sweden to another country lie in the concept of warm and cold rent. Most households in Sweden have warm rent and this is a central reason the population group remains understudied concerning energy vulnerability. In most countries, the tenants are solely responsible for the cost of heating, unlike in Sweden where the landlords have historically taken responsibility for the operating cost. As such, the findings of this study discussed in section 7.2, should be limited to the Swedish population.

Nevertheless, the onset of the energy crisis is currently changing how flexibility, energy vulnerability, and energy policies are experienced. For that reason, academics will have to keep track of these changes during these dynamic times. Concerning this study's findings, factors such as knowledge, agency, and the perceived ratio between disposable income and the cost of energy should be understood not only as barriers, but as enablers. Future research should explore how these socio-technological experiences are embedded in the Swedish context, and how they may enable or limit the energy transition as we move towards demand side responses. I also suggest future research to include the lower-end income groups which were excluded in this study. This would entail households consisting of low wages, part-time workers or the unemployed.

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Appendix A – Survey introduction

In Sweden, there is relatively little research on households' energy vulnerability and ability to adapt their energy consumption. This study therefore intends to inform the Swedish energy and housing policy about the household's experiences and eventual vulnerabilities.

The study is aimed at multifamily households and within electricity area 3-4 and constitutes a master´s degree project in political science.

The survey has two main purposes. The first purpose is to examine the relationship between the composition of the household and its perceived ability to adapt its energy consumption.

The second purpose is to produce a selection of interview candidates for further study. I would therefore greatly appreciate if you leave your contact details so that I can get in touch. This is of course voluntary. You are welcome to answer the survey even if you choose not to provide contact details.

The study is politically independent. Your data will be processed in accordance with GDPR, and as a representative of Lund University I assure you that your data will be processed anonymously and according to research ethical principles.

If you have any question, please feel free to contact me (Kevin Perera) at…….

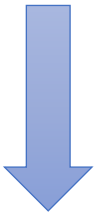
Appendix B – Survey variables

Red indicates theoretically derived variables. The rest are general.

Variable values

Variable 1-10	Value 1	Value 2	Value 3	Value 4	Value 5	Value 6	Value 7
Gender	Male	Female					
Electricity area	S3	S4					
Internet usage	Every day	A few times/week	A few times/month	Rarely			
"Awareness of electricity price(1-10)							
Education	No secondary ed	Secondary ed (max 2 years)	High school ed (3 years)	Post-secondary ed (less than 3 years)	Post-secondary ed (3 years or more)		
Activity situation	Unemployed	Full-time employment	Part-time employment	Student	Retired		
Disposable income (in the thousands)	0-300	300-500	500 or more				
Household lease	Multifamliy household	Terraced house	Single-family household	Student housing	Other		
What is included In the rent? warm/cold	Heating + water	Neither heating nor water	Heating but not water				
How is your Household heated?	Elecrticity heating, diret current	Electricity heating, water	Electricity heating + biofuels	Heatpump/geo thermal	Central heating	Oilheater	Don't know
How many adults live In the household?	1	2	3	4	5 or more		

Variable 11-18	V1	V2	V3	V4	V5	V6	V7
How many children live in the household?	0	1	2	3	5 or more		
Electricity area	S3	S4					
What electricity agreement do you have?	Hourly	Variable	Fixed				
Who takes the most responsibility for electricity consumption in the household?	I do	Someone else (male gender)	Someone else (female gender=	We share the responsibility equallty	I don't know		
Have you had to actively see to your habits to deal with your electricity consumption?	Yes	No					
To what degree have you had to change your lifestyle? (1-10)							
Have you had to save on other expenses to deal with your electricity consumption?	Yes	No					
The electricity prices are volatile. To what degree do you experience the ability to decrease your costs? (1-10)							



"What is your experience surrounding following statements; concerning your ability to shift energy intense activities to hours of low cost? "

Variable 19-22	V1	V2	V3	V4	V5	V6	V7
A: " It is possible for me to decrease or shift energy intense activites"	I agree	I partially agree	I partially distance myself	I completely distance myself	I don't know		
B: "I would shift or decrease energy intense activites to decrease my energy or climate impact"	I agree	I partially agree	I partially distance myself	I completely distance myself	I don't know		
C: "I can without problem pay extra to avoid decreasing or shifting energy intense acitivites	I agree	I partially agree	I partially distance myself	I completely distance myself	I don't know		

Appendix C – Interview questionaire

Name	
Gender	
Age	
Time and place	
Contact information	

Nr	[Type] & [theme]	Question
1	**General question**	• Tell me about your daily routines, how does a typical day look like for you?
2, 3	**Demand flexibility**	• In your household you arranged [x] electricity agreement, why did you choose to do that? • What are your thoughts on hourly agreements?
4, 5	**Income & energy**	• Can you tell me about your experiences surrounding the cost of electricity for your houeshold? • How do you perceive the relationship between your income and your ability to mitigate the cost of electricity?
6, 7, **8**	**Flexibility capital + income**	You answered (within the survey) that you had [x] ability to decrease your expenses, • Why do you think that is? - How would you say that this have affected your lifestyle? • In the statement: ”It is possible for me to decrease or shift energy intensive activites to hours of low cost” (you answered [x]. Why do you think that is? - How do you experience your will to adapt your habits? • What are your thoughts concerning your current ability to invest in energy efficient devices?

9	**Agency/income**	• How would you describe your relationship with your landlord/housing association? - Do you think that your landlord/housing association would listen to your demands/ideas?
10	**Demand flexibility**	There are indications that the state will eventually tax consumers that use a lot of electricity when the price is at its highest. This is called a power tariff. • What are your thoughts on this?
11	**Moving forward**	• Moving forward, what is your outlook on the Swedish energy landscape?

Appendix D – Interview Respondents

Respondents	Income group (A+B)	Date of interview
Kalle	A	2022/12/13
Johanna	A	2022/12/17
Ingrid	A	2022/12/22
Helena	A	2022/12/06
Bengt	A	2022/12/20
Lina	B	2022/12/08
Joakim	B	2022/12/12
Ylva	B	2022/12/09
Magnus	B	2022/12/13