Flexi-Sync

Flexible energy system integration using
concept development, demonstration and replication

END-USER FLEXIBILITY POTENTIAL

VERSION 1.0

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EXECUTIVE SUMMARY

Flexibility in district energy systems can be realised in many different ways and one of them is to allow for greater variations in indoor temperature. The aim of this task has been to understand what impact greater variation in indoor temperature can have on the comfort of occupants of such spaces. This understanding was gained through (1) a scholarly literature review, (2) creating three plausible flexibility scenarios for residential buildings, (3) collecting residents' opinions about these three scenarios through a survey, and (4) through a stakeholder workshop.

Unfortunately, as the survey had a very low response rate and the workshop had few participants, the result should be interpreted with caution unless corroborated by previous literature. The findings that were corroborated by previous findings show that there are more aspects than the range in which the temperature is allowed to vary that is important for the acceptance of varying indoor temperature. First, it is important that occupants understand the flexibility setup, but it is difficult to inform in an understandable and accessible way. When and where (e.g., in the bathroom or bedroom) the variation takes place is also important and, to complicate matters, people often have specific and individual preferences regarding heating. Pricing models that incentivize variation in indoor temperature could enhance the acceptance rate of minor comfort losses.

The survey also resulted in interesting indications to be confirmed or rejected in future studies. For example, the survey showed that the respondents prefer flexibility setups in which they have control over the flexibility range and are compensated economically for ranges larger than ±0.5°C (Scenario 3) over flexibility setups with the same variation and no control (Scenario 1) and larger variations without control (Scenario 2). But interestingly, some respondents showed a willingness to accept a deterioration of the heating service without any compensation. In the survey, younger residents (aged 18 to 34) showed the highest acceptance of a heating service deterioration without compensation. The survey respondents' satisfaction with their current heating seemed to influence the extent to which they accepted higher variations in indoor temperature. Finally, the survey indicated that if you spend more time at home, you will have higher demands on thermal comfort.

CONTRIBUTION

Main contributors to this deliverable are Sara Renström and Sofie Nyström from RISE and Burcu Ünlütürk from IVL. We would also like to thank Lukas Lundström and Parsa Javadi Mohammadjavad at Eskilstuna kommunfastigheter who played a crucial role in the creation and distribution of the end-user survey. Additionally, Carolin Monsberger from AIT shared the outputs of the stakeholders' workshop which was held at the demonstration site in Maria Laach am Jauerling in Austria.

Thank you, all Flexi-Sync project members who participated in our workshop, responded to our internal survey, and gave feedback on end-user questionnaire.

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Finally, we would like to extend a heartful thank you to all anonymous survey respondents who so generously contributed with their time and engagement.

1 INTRODUCTION

Flexibility in district energy systems can be realised in many different ways, as the Flexi-Sync project also will show, for example through better sector coupling, through thermal energy storage in hot water tanks, or through storing heat in buildings and in doing so allowing for greater variations in indoor temperature. While some of these ways to increase flexibility have more of an indirect effect on occupants of a space, such as an effect on the economy of the energy company that provides the district energy, allowing for greater variations in indoor temperature could have a direct effect on occupants' comfort. The aim of deliverable 5.3 is therefore to:

> "understand what impact the increased flexibility can have on the comfort of the end-user and to understand constraints for flexibility from the end-user side" (Flexi-Sync project application, p. 26).

It is worth reflecting over who the *end-user* of district energy is as who is considered in the aim, as it was expressed in the application, especially since the term *end-user* means different things for different fields of energy research. Is a building the end-user? One floor in a building? One apartment? The building owner? The district energy utility's customer? The resident in a home, in a house, or an apartment? A tenant? Or the occupant of a space that is heated or cooled with district energy? But since the aim quoted above includes investigations of *comfort*, the interpretation of end-users as residents of a home or as visitors, i.e., occupants of the space, is the most meaningful; residents and other occupants can experience comfort (a building cannot) and residents'/occupants' comfort could be affected (while the comfort of the building owner or the utility's customer is not necessarily affected since they might live elsewhere).

In this report the term occupant will be used as a general term to denote a person that is in a space, an office, a home or other. The term resident will be used when we wish to specifically point out that an occupant of a space also lives in that space and therefore might be affected by that space's thermal conditions for longer period of times, that the occupant might have more knowledge about and influence over the workings of that space's heating system, and that the resident occupant might – directly or indirectly – be economically influenced by the energy use in that space.

1.1 What is comfort?

Comfort is affected by many things, but in the context of district energy we have focused on *thermal* comfort. Thermal comfort can be understood in two different ways, either as something that can be provided by an environment (comfort-as-product) or as something that occupants pursue as a part of everyday life (comfort-as-goal) (e.g, Clear, Morley, Hazas, Friday, & Bates, 2013; Nicol & Humphreys, 2009). In this approach, occupants use different means for personal thermal comfort and the heating system is one of these means. Other means can be blankets, clothing, hot drinks, adjustment of windows, or ventilation, etc. (e.g., Clear, Friday, Hazas, & Lord, 2014; Renström, 2016; Renström & Rahe, 2013). Over the last two decades, the comfort-as-goal approach – also called the adaptive approach – has gained recognition and there are standards based on both understandings (de Dear et al., 2013). It is important to understand both of these approaches, even though building managers and owners as well as district energy utilities

today usually only influence the temperature and do not provide additional means for thermal comfort. With the adaptive approach, it also becomes clear that the comfort of occupants is not a direct consequence of the indoor temperature, but that there are many factors to take into consideration to fully understand how increased flexibility could impact the thermal comfort of occupants.

1.2 Research questions

To understand what impact increased flexibility could have on residents' and/or occupants' comfort the following two research questions were formulated.

- **Research question 1:** What impact could the increased flexibility have on residents' and/or occupants' comfort? (RQ1)
- **Research question 2:** What are the constraints for flexibility from the residents' and/or occupants' side? (RQ2)

In these questions both residents and occupants are included as they both could be affected, but potentially differently. Residents, meaning someone who lives in a space, are in the affected space regularly but they are also *at home* with access to a variety of additional means for thermal comfort (for example a blanket or a warmer sweater) and have some basic understanding of how to operate or control the heating system. Occupants of a space might not have the same access to additional means for thermal comfort (e.g., you might not have an extra blanket at the office) and might not be allowed to influence the heating. In the Flexi-Sync project both homes and public spaces (offices and university premises) will be used as demonstration sites (although it is worth noting that there are also other types of public spaces that are heated with district heating).

1.3 Research approach

As the research questions concern people's subjective opinions – especially in the light of the adaptive approach –about something that is not yet widely present, we decided to use subjective valuations of possible future flexibility setups as the main research method. To create the scenarios and to identify important knowledge gaps we initiated the work with a literature review. Ideas for the scenarios were then created in a workshop with Flexi-Sync project members and refined based on the literature review. The result was reviewed by the project members. Finally, the scenarios were, together with complementary questions, put in a questionnaire that was distributed in Sweden to tenants in a demonstration site consisting of residential buildings, residents in other buildings and through social media. The result was analyzed, and the findings were compared with the previously reviewed literature. Insights from a stakeholder workshop in Austria were then used to complement the predominantly Swedish perspective in the survey findings.

2 LITERATURE REVIEW: END-USER FLEXIBILITY

First, a literature review was conducted. The review resulted in insight about the possible impact and constraints for flexibility through variable indoor temperature, important occupant-related aspects of implementation of flexibility through variable indoor temperature and identified gaps in the current knowledge.

2.1 Method

To create possible scenarios and to make sure to contribute to new knowledge, we started with a literature review. Through the literature review, we sought to find:

- what impact could flexibility through variable indoor temperature have on occupants, if any (primarily RQ1);
- if any constraints in relation to variable indoor temperature are suggested (primarily RQ2);
- what occupant-related aspects of the implementation of flexibility through variable indoor temperature seem important, if any (primarily RQ2);
- examples of how flexibility through variable indoor temperature previously have been implemented (RQ1 and RQ2); and
- knowledge gaps in relation to the above-mentioned areas (RQ1 and RQ2).

Scholarly literature was found using backward and forward snowballing (cf. Wohlin, 2014) based on a relevant set of papers that was found using Google Scholar and combinations of different variants of the keywords "district heating", "district energy", "demand response", "demand side management", "household", "thermal comfort", "occupant", and "smart home".

Based on the literature, we defined a tentative set of important occupant-related aspects of implementation of flexibility through variable indoor temperature, hereafter referred to as *occupant-related aspects of flexibility*. This list was developed throughout the work, for example through subsequent workshops.

2.2 Findings from literature review

2.2.1 Set point temperature or comfort spans

The temperature in an apartment varies naturally due to many different factors from external factors, such as the outside weather, to internal and behavioural factors, such as if the windows are open, the number of occupants, what appliances are being used, etc. The temperature impact occupants thermal sensation, and in the 70's Fanger (1970) developed what is now an established model to calculate a recommended set point temperature. The model, called Predictive Mean Vote calculates the recommended set point temperature based on activity level, clothing, air temperature, mean radiant temperature, relative air velocity, and air humidity. The reason for recommending a set *point* temperature and not a temperature *span* is that although individuals have spans in which they are comfortable – comfort spans – and these spans vary between individuals and can mismatch with each other. These mismatches decrease the span in which many are comfortable, and Fanger (1973) therefore argues for providing a set *point* temperature. According to the Predictive Mean Vote model, 5% of the occupants of a space will be dissatisfied at the set point temperature, 10% of the occupants will be dissatisfied at ±0.5°C, and at ±2°C 80% will be dissatisfied (Fanger, 1970). Fanger (1973) provides examples of applying the Predictive Mean Vote model in public places occupied by groups of people: offices, warehouses, and busses. But, as apartments usually are occupied by much fewer people than public places, the issue with mismatching comfort spans should be less prominent and using the use of temperature span instead of a set

point temperature more feasible. Flexibility in terms of increased variation in indoor temperature means of course temperature spans, but usually the set point temperature is taken as a starting point. Another way could be to take occupants' comfort spans as starting points and allow for variation within that span (Renström, 2016)

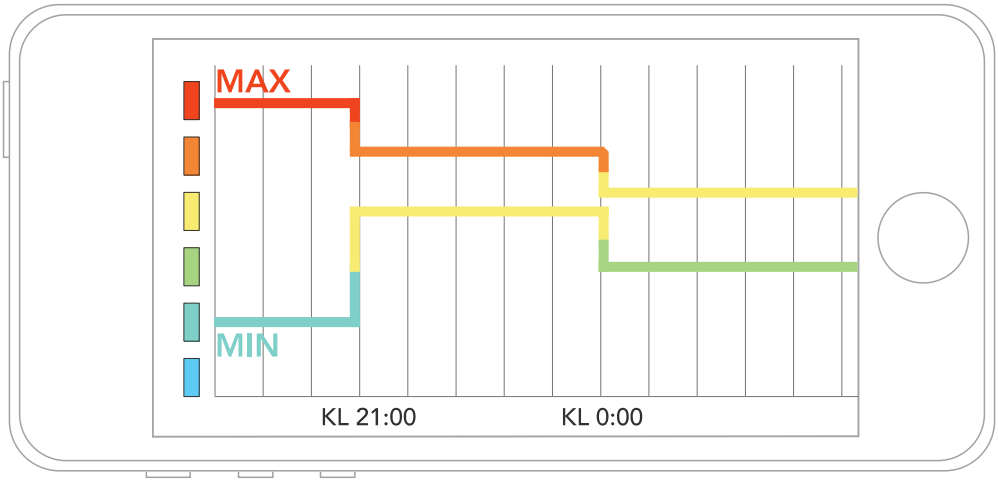


Figure 1 An early, conceptual idea of the graphical user interface of an app in which residents can set their preferred temperature spans over the day to allow for variation that is based on comfort spans and not around a set point temperature *(Renström, 2016)*.

2.2.1.1 Knowledge gap: variation within comfort spans

To our knowledge, there are no experimental studies that have used the idea of comfort spans as the span in which the temperature is allowed to vary. It should increase the perceived comfort, as the temperature would stay within people's comfort spans, but there is a risk that the mean temperature would increase as increased control over indoor temperature can contribute to an overall higher temperature (Larsen & Johra, 2019).

2.2.2 Variation around a set point temperature: communication and impact

First, there are not many experimental studies that explore the impact that increased flexibility in terms of increased indoor temperature variation could have on residents' and/or occupants' comfort. There are two studies in which the residents were not informed about the flexibility set up and in these, the residents' experiences were not directly investigated. There is one study in which no actual reduction in indoor temperature was detected, and there were (thus) no complaints from residents (Wernstedt, Davidsson, & Johansson, 2007). A study in which the temperature was allowed to vary ±0.5°C around the set point resulted in no increase in the frequency of complaints during the test period, according to the landlord (Kensby, Trüschel, & Dalenbäck, 2015).

There are also examples of studies in which the occupants are informed that variations in temperature will occur, but not informed about when the changes would happen. In an office environment, Salo and colleagues (Salo, Jokisalo, Syri, & Kosonen, 2019) tested three different variation spans: ±0.5°C, ±1°C, and ±2°C. They found that the variation decreased the perceived thermal comfort and that the respondents were the least satisfied on days with ±2°C. In a study with 28 households, the temperature was allowed

to vary within the span of ±1°C around the set point, a set point that the participants could set themselves (Sweetnam, Spataru, Barrett, & Carter, 2019). The paper report that some of the participants at times had felt slightly or uncomfortably warm and that they had noticed unusual operation of the heating system. Hagejärd and colleagues (Hagejärd, Dokter, Rahe, & Femenías, 2021) also investigated the perception of households of flexibility set up with ±0.5°C. They found no significant difference in thermal sensation and satisfaction between days with and without load shifts. Interestingly, many residents may be more concerned about the temperature for the comfort of family members, guests, and pets than themselves (Sugarman & Lank, 2015).

As far as we have understood, none of the studies have provided occupants with forecasts of the expected indoor temperature. Such forecasts would allow for occupants to prepare for use of other means for thermal comfort, for example, to bring a warm enough sweater to the office. An analogy can be made here with how we maintain thermal comfort outdoors. Then, many of us use temperature forecasts to maintain thermal comfort within a great span. Further, occupants might want to know how the system is operating, for example, if the temperature currently is declining or rising (cf. Renström, 2016) or to better understand how the system operates, as Sweetnam and colleagues point out. They also note the importance of the quality of the information: "[…] careful consideration must be given to the quality of the information provided to participants when deploying these systems commercially. Clear explanations about how the system operates, how this may differ from their expectations, what they can do to ensure their comfort requirements are met and, significantly, the benefits that their participation brings both to the overall [district heating, authors interpretation] network and to them as individuals should be provided to avoid raising concerns and reducing participation." (Sweetnam et al., 2019, p. 341)

2.2.2.1 Knowledge gap: communication and impact of different temperature spans

In terms of variation within different temperature spans, there are just a few studies in which the temperature variation is more than ±0.5°C and there is none in which the occupants are informed about upcoming temperature variations (cf. argumentation in Hagejärd et al., 2021). It would be interesting to investigate under which circumstances a wider range than ±0.5°C would be accepted and further investigate what impacts such ranges could have on occupants' comfort.

2.2.3 Space, timing, and duration

Variation in indoor temperature is not only a matter of the magnitude of the variation but where the temperature is varied, when, and how. Previous research has shown that people for example can perceive themselves as more sensitive towards high or low temperatures in the bedroom or bathroom, but that these preferences are very personal (e.g., Renström & Rahe, 2013). In an experiment of varying indoor temperature in apartments, Christiansen and colleagues (Christensen, Li, & Pinson, 2020) found that participants in the trial had strong objections against losing control over the temperature and not having control over potential temperature variations in their bathrooms in the morning hours. Bathrooms were therefore omitted from the experiment.

When it comes to the timing, the morning seems to be a period where apartments can be perceived as cold (Hagejärd et al., 2021) and a time when occupants are afraid of

losing control over their heating (Christensen et al., 2020). The timing is of course also important from the perspective of the energy system since the whole idea is to use less energy during peaks in demand. Here, it could be vital to choose wisely between two different modulations of temperature (Le Dréau & Heiselberg, 2016): either pre-heating the apartment (i.e., heat storage or increase of set-point) or allowing the temperature to drop (i.e., heat conservation or decrease of set-point).

In addition to the temperature variation and timing of that variation, when it comes to the duration of the temperature variations there seems to be little knowledge of suitable maximum length from an occupant perspective. In one trial, two hours was considered the minimum duration when it comes to the flow temperature (note, not the indoor temperature) as less time is not efficient due to buildings' thermal inertia (Le Dréau & Heiselberg, 2016). In the same trial 24 hours was considered the maximum duration of an offset in indoor temperature as occupants, in that experiment, were not assumed to accept a longer duration than that. But, if the temperatures are within the comfort zones of the residents, or at least above the recommendations, there is no reason why longer periods should not be accepted.

2.2.3.1 Knowledge gap: space, timing, and duration

There are indications that space, timing, and duration or variations in temperature could influence the acceptance of flexibility set up and that the effect is different from individual to individual. More research is needed to understand how these factors influence the acceptance.

2.2.4 Control

Many studies have shown that occupants want to have control over their heating and that control is important for satisfaction. This has been shown in studies without varying indoor temperature (Bauman, Carter, & Baughman, 1998; Boerstra, Loomans, & Hensen, 2013; de Dear et al., 2013; Renström, 2016) as well as with varying indoor temperature (Hagejärd et al., 2021; Sweetnam et al., 2019). One study has shown the opposite (Larsen & Johra, 2019). In one trial of a system called the *peaksaver,* the fear of loss of control of temperature variation was explained in a good way (although it concerned electricity use, particularly for air condition):

> "We found a number of participants who were not opposed to the small or imperceptible reduction in comfort from peaksaver, but the specific implementation details turned them off – specifically the idea of an outsider having control, with limited ability to opt out in the moment. Giving consumers ultimate control over adjustments and thus the ability to opt out in the moment using the thermostat would reduce this fear. One concern of the designers of peaksaver was that people could in theory opt out en masse at the times when changes were most needed. However, in practice, peaksaver participants were unaware of the changes, so this is unlikely to be the case." (Sugarman & Lank, 2015, p. 1981)

2.2.4.1 Knowledge gap: control

There is not a lack of knowledge about how important control over heating is to residents, but it is less known what can be the effects of providing control, for example,

when, how and to what extent increased control can contribute to an overall higher temperature (cf. Larsen & Johra, 2019). There is also a question of what to have control over in a flexibility set up. The acceptable deviation from the set point temperature? Where the variation can be applied (e.g., in the kitchen but not in the bathroom)? Just simple opt in or opt out? Or the set point temperature?

2.2.5 Incentives

If occupants are not informed about the intentional variation in temperature, any incentives to occupants are of course not relevant (see, e.g., Kensby et al., 2015; Wernstedt et al., 2007). But even though residents are informed, there are not necessarily any particular incentives (cf. Hagejärd et al., 2021). There are of course many studies where residents are economically rewarded for lowering the indoor temperature in homes where the heating is included in the rent (as is common in Sweden). One example from Sweden in 2005 was that 21°C was included in the rent, and -1°C lowered the rent with 5 SEK/m^2 and +1°C increased the rent with 5 SEK/m^2 (Socialstyrelsen, 2005). There are few studies in which flexibility in district heating systems is economically compensated. But, Sweetnam and colleagues (2019) found in their flexibility trial that 11 out of 13 would continue to participate in the flexibility set up for £5/month and 7 out of 13 for £2/month. To our knowledge, few studies have used other types of incentives or to motivate use by contributing to a collective effort for the environment, although this could be an interesting path forward: "One positive aspect that interviewees brought up about the peaksaver program was that it supports collective action. P5 says she likes that it works on 'a collective rather than an individual basis'." (Sugarman & Lank, 2015, p. 1980)

2.2.5.1 Knowledge gap: incentives

For heating customers that pay directly for their heating and have different on- and off-peak pricing, economic savings are already a part of the deal. But that does not apply to all other occupants, including for example people at work. There is little knowledge about if and how they should be incentivised, and little knowledge of the alternatives to economic incentives.

2.2.6 Important occupant-related aspects of flexibility

A tentative set of important occupant-related aspects of flexibility was developed based on the literature review. This list was expanded, adapted and reorganised into a final set throughout the project. The final set is listed below, with reference to literature and other sources of origin.

Aspects related to *temperature* (cf. Salo, Jokisalo, Syri, & Kosonen, 2019)

- Temperature set-point, e.g., 21°C (Salo et al., 2019)
- Maximum temperature span, e.g., set-point temperature ±1 °C
- The lowest and highest (if applicable) temperature allowed

Aspects related to the *rate of change & duration* (cf. Le Dréau & Heiselberg, 2016)

- Rate of change, i.e., how fast can the temperature drop?
- Maximum duration of lowest and highest temperature

Aspects related to the *time of the day & day of the week* (cf. Hagejärd, Dokter, Rahe, & Femenías, 2021; Péan, Ortiz, & Salom, 2017; Sweetnam, Spataru, Barrett, & Carter, 2019)

- Different set-points and temperature spans depending on the time of the day, e.g., ±1.5 °C at night and ±0.5 °C in the morning
- Different set-points and temperature spans depending on the day of the week, e.g., ±1 °C on weekdays and ±0.5 °C at weekends

Aspects related to *location* (cf. Christensen, Li, & Pinson, 2020)

- Different set-points and temperature spans depending on location, e.g., ±1 °C in bedroom and ± 0.5 °C in bathroom

Aspects related to *seasons & unusual events* (aspect discussed in workshop, see section 3)

- Different set-points and temperature spans depending on season and unusual events, e.g., very cold winter mornings

Aspects related to *information to occupants* (cf. Hagejärd, Dokter, Rahe, & Femenías, 2021; Sweetnam et al., 2019)

- Which information is provided to occupants, if any
- If occupants get to know the "mode" and "plans" of the heating system, e.g., indoor temperature forecasts

Aspects related to *incentives* (cf. Sweetnam, Spataru, Barrett, & Carter, 2019)

- If occupants participance in the flexibility program is incentivised, e.g., economically, sense of contributing

Aspects related to *voluntariness & control* (cf. Hagejärd et al., 2021; Sugarman & Lank, 2015; Sweetnam et al., 2019)

- If occupants can opt-in/out of the flexibility program, or not
- If it works on a collective basis, or not
- If occupants are given control over some aspects of flexibility

Aspects related to home adaptations & equipment (cf. Hagejärd et al., 2021; Mishra et al., 2019)

- If the home is adapted or equipped differently, e.g., better insulation or equipped with "smart" heating devices

3 OCCUPANT SCENARIOS FOR FLEXIBILITY

Through the literature review we identified important occupant-related aspects of flexibility and examples of how flexibility previously has been implemented. Based on this, we created three scenarios for implementing flexibility through variable indoor temperature from the perspective of occupants, hereafter referred to as *occupant scenarios for flexibility*.

3.1 Method

Based on the tentative set of important occupant-related aspects of flexibility defined in the literature review we created a workshop with the aim of collecting Flexi-Sync project members' views on these aspects. Project members from Sweden and Austria were present. In the workshop, the participants were asked to answer questions related to the aspects, see Figure 2.

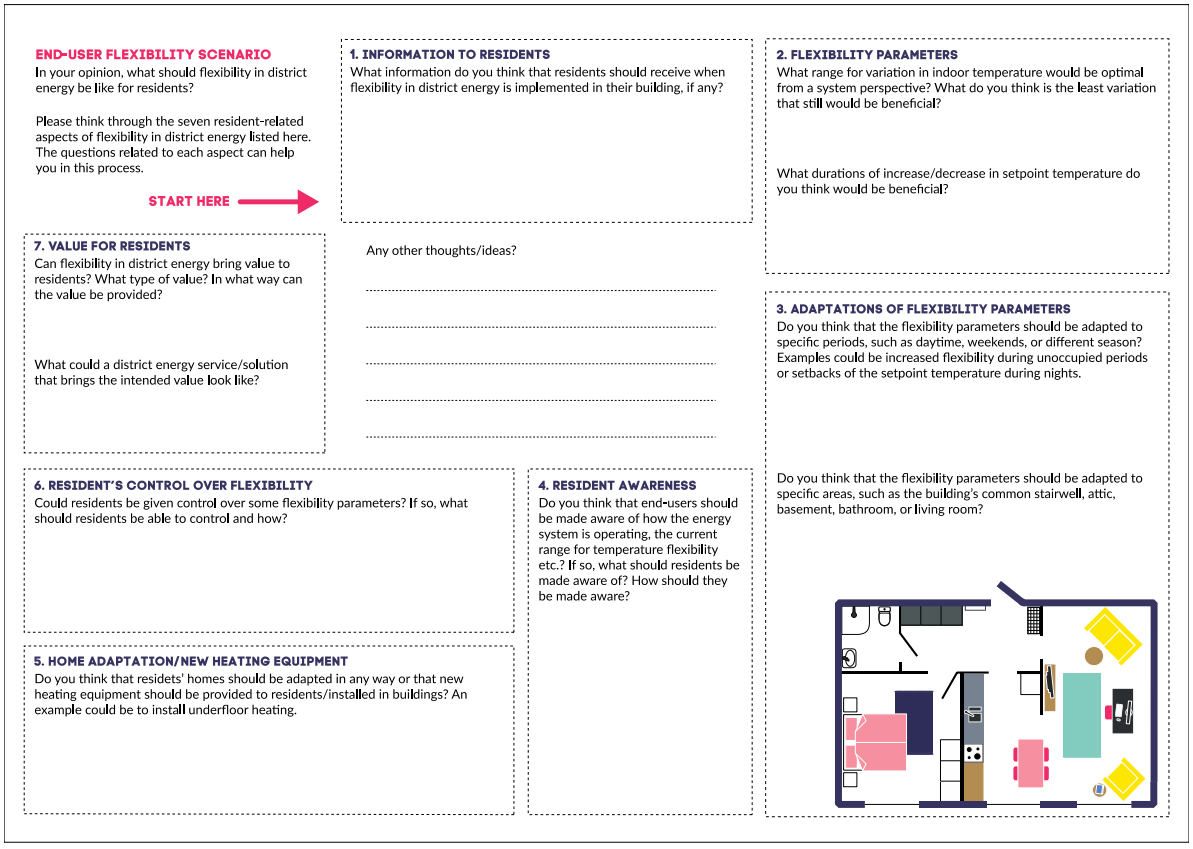


Figure 2 Workshop canvas with questions related to the tentative set of important occupant-related aspects of flexibility.

The answers to the questions related to the tentative set of aspects were then summarised and, with input from examples of how flexibility through variable indoor temperature previously has been implemented as well as the identified knowledge gaps, reworked into three plausible occupant scenarios for flexibility. We created *plausible* scenarios rather than *possible* or *probable* scenarios as such scenarios would not have contributed as much to fill the knowledge gaps. The three scenarios were then sent out for review to Flexi-Sync project members and refined based on the review. Finally, all scenarios were written as stories from the perspective of tenants in Sweden and in a non-expert language. The way that tenants control their heating and pay for heating differs,

especially in different regions in Europe. The scenarios would, to be understandable, have to be adapted to these different set-ups. As the majority of demonstration sites are situated in Sweden, we chose to adapt the scenarios to Swedish preconditions and to investigate the residents' opinions in Sweden.

3.2 Final occupant scenarios for flexibility

The scenarios were first created based on the occupant-related aspects of flexibility and then reworked into written stories from the perspective of occupants.

3.2.1 Occupant scenarios and occupant-related aspect of flexibility

In Table 1, the three occupant scenarios for apartments are outlined in relation to the final set of occupant-related aspects of flexibility.

Table 1 Three occupant scenarios for apartments and their relation to occupant-related aspects of flexibility presented in 2.2.6.

Type of aspect	Aspect	Scenario 1	Scenario 2	Scenario 3
n/a (no type of aspect, basic information about the scenarios)	*n/a*	Small variation that does not affect comfort	A little more variation that is extra good for the environment	You decide how much variation you think is okay
	n/a	Maintained comfort	Most negative impact reduction	Occupant control and incentives
Temperature	*Temperature set-point*	Not affected (in the written scenarios 21°C)	Not affected (in the written scenarios 21°C)	Not affected (in the written scenarios 21°C)
	Maximum temperature span	±0.5°C	±1°C or ±1.5°C on normal days depending on time of the day ±3°C on extremely cold winter days, see below	From ± 0.5°C to ± 3°C depending on occupant's choice
	Lowest temperature allowed	Based on set-point (in the written scenarios 20.5°C)	Based on set-point on normal days (in the written scenarios 20°C or 19.5°C depending on time of the day, 18°C on "extremely cold winter days)	From 18°C to 20.5°C depending on occupant's choice
	Highest temp allowed during heating season (non-heating season temperature is disregarded due to no active cooling in most residential buildings in Sweden)	Based on set-point (in the written scenarios 21.5°C)	Based on set-point on normal days (in the written scenarios 22°C or 22.5°C depending on time of the day, 24°C on "extremely cold winter days)	From 21.5°C to 24°C depending on occupant's choice

Type of aspect	Aspect	Scenario 1	Scenario 2	Scenario 3
Rate of change and duration	*Rate of change*	Maximum 2°C per hour (not discussed much in literature, decisions based on ISO 7730 standard as cited in Salo et al., 2019, p. 948).	Maximum 2°C per hour	Maximum 2°C per hour
	Maximum duration of lowest and highest temperature	Indefinite (the lowest and highest temperature is within the recommended temperature span (Folkhälsomyndigheten, 2020))	Indefinite on normal days, daytime (the lowest and highest temperature is within the recommended temperature span (Folkhälsomyndigheten, 2020)) On extremely cold winter days 18°C for maximum 48 h (to our knowledge there is no recommendation that can be followed here)	Based on occupant's choice
Time of the day and day of the week	*Different set-points and temperature spans depending on time of the day*	No	±1 from 5 AM to midnight, ±1.5°C from midnight to 5 AM	Based on occupant's choice
	Different set-points and temperature spans depending on day of the week	No	No	Based on occupant's choice
Location	*Different set-points and temperature spans depending on location*	No	No	Occupants can set different set-points and temperature spans for every room (as, in Christensen et al., 2020 bathrooms had to be omitted from the flexibility scheme due to residents' negative perception of cold bathrooms)
Seasons & unusual events	*Different set-points and temperature spans depending on season and unusual events*	No	± 3°C on extremely cold winter days, minimum 18°C and for 48 h at the most, notification of occupants in advance	Asked to accept higher flexibility ranges on extremely cold winter days, minimum 18°C

Type of aspect	Aspect	Scenario 1	Scenario 2	Scenario 3
Information to occupants	*Which information is provided to occupants*	No information	Information to residents about the flexibility set up and that this is a collective effort	Information to residents about flexibility set up and how to control the flexibility
	If occupants get to know the "mode" and "plans" of the heating system, (i.e., indoor temperature status and forecasts)	No information	Only that occupants are notified in advance about extremely cold winter days	Occupants control the mode and plans and can access a forecast of the expected temperature
Incentives	*If occupants participance in the flexibility program is incentivised*	No	Incentivized in the sense that occupants are told that they contribute to reducing negative environmental impact	Temperature ranges of more than ± 0.5°C are incentivized, from 200 to 500 SEK per year (circa 20 to 50 €)
Voluntariness & control	*If occupants can opt-in/out*	No	No	No
	If it works on a collective basis or not	Yes, but not communicated as such	Yes, and included in the communication	No
	If occupants are given control over some aspects of flexibility	No	No	Yes, can have different settings in different locations, time of the day, days of the week, etc., for details see above
Home adaptations & equipment	*If the home is adapted or equipped differently*	No home adaptations, except measurement equipment	No home adaptations, except measurement equipment	Demands smart thermostats and a control system (e.g., an app)

3.2.2 Written flexibility scenarios – from the perspective of occupants

The final version of the three scenarios written as stories from the perspective of residents in apartments can be found below. The Swedish version of the scenarios can be found in Annex B – Scenarios in Swedish.

3.2.2.1 Scenario 1 – Small variation that does not affect comfort

In this option, the heat in the apartment building where you live is optimized with the goal of using energy in a way that is better for the environment without affecting your comfort. Temperature measurement equipment is installed in some apartments that make it possible to follow, and in some cases, improve indoor comfort. Certain controlled temperature variation is allowed and for most apartments that means more variation than today. The average room temperature is the same as before.

The controlled variation of the room temperature is in Option 1 at most 0.5 degree Celsius above or below your current room temperature (apart from natural variations in temperature due to, for example, ventilation). It is the same variation in the whole building and both day and night.

You and the other tenants do not receive any information that the housing and energy company is trying to heat the apartments in this way as research has shown that such small variations do not affect comfort.

3.2.2.2 Scenario 2 – A little more variation that is extra good for the environment

In this option the heating in the building where you live is adapted with the goal of using energy in a way that is better for the environment. Temperature measurement equipment is installed in some apartments that make it possible to follow, and in some cases, improve the indoor comfort. Certain controlled temperature variation is allowed and for most apartments that means more variation than today. The average room temperature is the same as before.

The controlled variation of the room temperature is in Option 2 at most 1 degree Celsius above or below your current room temperature (apart from natural variations in temperature due to, for example, ventilation). From midnight to 5 o'clock in the morning, the temperature varies at most 1.5 degrees Celsius above or below your current room temperature.

The energy provision is the most strained and more dependent on fossil fuels when the weather is at its coldest. To use as little fossil energy as possible, the room temperature varies more on really cold days. But the temperature must never be lower than 18 degrees Celsius. It may be so for 48 hours at the longest and at most it may be 10 such days in a year. You will be notified in advance when such cold days are approaching.

3.2.2.3 Scenario 3 – You decide how much variation you think is okay

In this option you move to a newly built apartment where new technology makes it possible for you and the other tenants to adjust your heating yourself. The goal is to heat the home in a way that is better for the environment. When you live in this apartment, you can choose to what extent you want to contribute to this goal.

In Option 3, you choose how much controlled temperature variation that you accept, from 0.5 degrees Celsius to 3 degrees Celsius above or below your current indoor temperature (apart from natural variations in temperature that depend on, for example, ventilation). You receive information about how and to what extent the temperature variation that you and the other tenants provide contributes to the environment. You also get a financial bonus if you choose to have more variation than 0.5 degrees Celsius.

You decide whether the variation in temperature should be the same all the time or if you want the variation to be greater or less, for example during nights or when no one is home. You can also have different variations in different rooms, for example in bedrooms and bathrooms.

The energy provision is the most strained and more dependent on fossil fuels when the weather is at its coldest. To use as little fossil energy as possible you will on really cold

days be notified that extra temperature variation would be favorable. You decide whether you accept this or not. The temperature is never allowed to be lower than 18 degrees Celsius.

You and the other tenants get to know how the heat works and it is easy to control the variation yourself, for example through an app.

4 SURVEY STUDY

When the plausible scenarios were created, these were incorporated into an online questionnaire intended for residents in apartments. The survey study resulted in 88 questionnaire respondents, and the result was then analysed and compared with existing literature.

4.1 Method

4.1.1 Questionnaire

The questionnaire was devised to provide subjective quantitative and qualitative data with relevance for RQ1 and RQ2: *What impact could the increased flexibility have on residents' and/or occupants' comfort?* and *What are constraints for flexibility from the residents' and/or occupants' side?* Links between themes and questions covered in the questionnaire and the research questions are presented in Table 2.

Table 2. Themes/questions covered in the questionnaire and how they correspond to the research questions.

Themes/questions in questionnaire	Purpose
Respondents current housing and heating system (i.e., radiators, floor heating, complementary electric heating/fireplace etc.)	Investigate possible correlation between housing/heating type and impact on comfort (RQ1) or constraints for flexibility (RQ2)
How the respondents live, including time spent at home and members in the household	Investigate possible correlation between time spent at home and social factors and impact comfort (RQ1) or constraints for flexibility (RQ2)
Respondents' current satisfaction with heating	Investigate possible correlation between current satisfaction and impact on comfort (RQ1) or constraints for flexibility (RQ2)
Respondents' acceptance of variation in indoor temperature (different ranges) and subjective valuation of how they would be affected (quantitative and qualitative (optional))	Contribute to answering RQ1 including acceptance of different ranges and possible subjective consequences of ranges wider than ±0.5°C
Respondents' acceptance of and preference for the three different occupant scenarios for flexibility (quantitative and qualitative (optional))	Contribute to answering RQ2, including how occupant-related factors of flexibility affect the acceptance of different ranges
Demographic information about respondents	Investigate possible correlation between demographics (especially age, educational level and level of income) and impact on comfort (RQ1) or constraints for flexibility (RQ2)

The questionnaire was created on Microsoft Forms in an iterative manner with feedback from the Flexi-Sync project group members. Especially the project member *Eskilstuna kommunfastigheter* contributed with highly valuable comments and ideas for improvements based on their understanding of and experiences with their tenants. The online questionnaire was created in Swedish and later translated to English. Both language options were available for the respondents, see both versions in Annex A – Questionnaire. The questionnaire, including the scenarios, was also pilot tested.

4.1.2 Distribution and respondents

The questionnaire was first distributed to tenants in Eskilstuna kommunfastigheter's demonstration site and to additionally 363 tenants in other buildings than the demonstration site.

Despite the reminders, the response rate was very low and thus there were very few respondents. Therefore, we tried to at least increase the number of respondents by expanding the number of recipients through social media marketing and by including a co-operative in Gothenburg. See Table 3 for details about the distribution and respondents. In total, the survey had 88 respondents. See

Table 4 for an overview of the respondents.

Table 3. The different groups of targeted respondents and details about the recruitment.

Targeted residents	Distribution of invitation	Reminder?	Response period	No. of respondents	No. of recipient	Incentives
Eskilstuna kommunfastigheter demonstration site, Eskilstuna, rental apartments	Flyer, see Annex C – QUESTIONNAIRE INVITATION FLYERS	Yes, one reminder	2021-01-15 to 2021-02-04	7	Circa 70 apartments	Gift certificate 250 SEK, lottery, one winner out of four
Eskilstuna kommunfastigheter, not demonstration site, Eskilstuna, rental apartments	E-mail	Yes, one reminder	2021-02-01 to 2021-02-10	15	363 e-mail addresses	Gift certificate 250 SEK, lottery, one winner out of six
A co-operative, Gothenburg co-operative apartments,	Flyer	Yes, one reminder	2021-01-26 to 2021-02-28	29	132 apartments	None
Social media, Sweden, any type of housing	Facebook and Instagram ad, see Figure 3	No	2021-02-14 to 2021-02-28	37	n/a	None

Table 4. Information about the survey respondents.

		Number of people	%
Total		88	100%
Age	**18-34**	21	24%
	35-49	19	22%
	50-64	21	24%
	65+	27	31%
Gender	**Female**	45	51%
	Male	42	48%
	Not answered	1	1%
Education level	**Lower than primary school level**	2	2%
	Primary school, realskola, folkskola or equivalent	5	6%
	Gymnasium, folk high school or equivalent	18	20%
	University, college or equivalent	63	72%
Income	**Under 100 000 kr**	8	9%
	100 000 – 199 999 kr	8	9%
	200 000 – 299 999 kr	17	19%
	300 000 – 399 999 kr	9	10%
	400 000 – 499 999 kr	10	11%
	500 000 – 599 999 kr	9	10%
	600 000 kr or more	15	17%
	Not answered	12	14%
Type of housing	**Flat**	71	81%
	Detached villa / Cottage	17	19%
Type of lease	**Tenancy**	43	49%
	Ownership	15	17%
	Condominium	30	34%

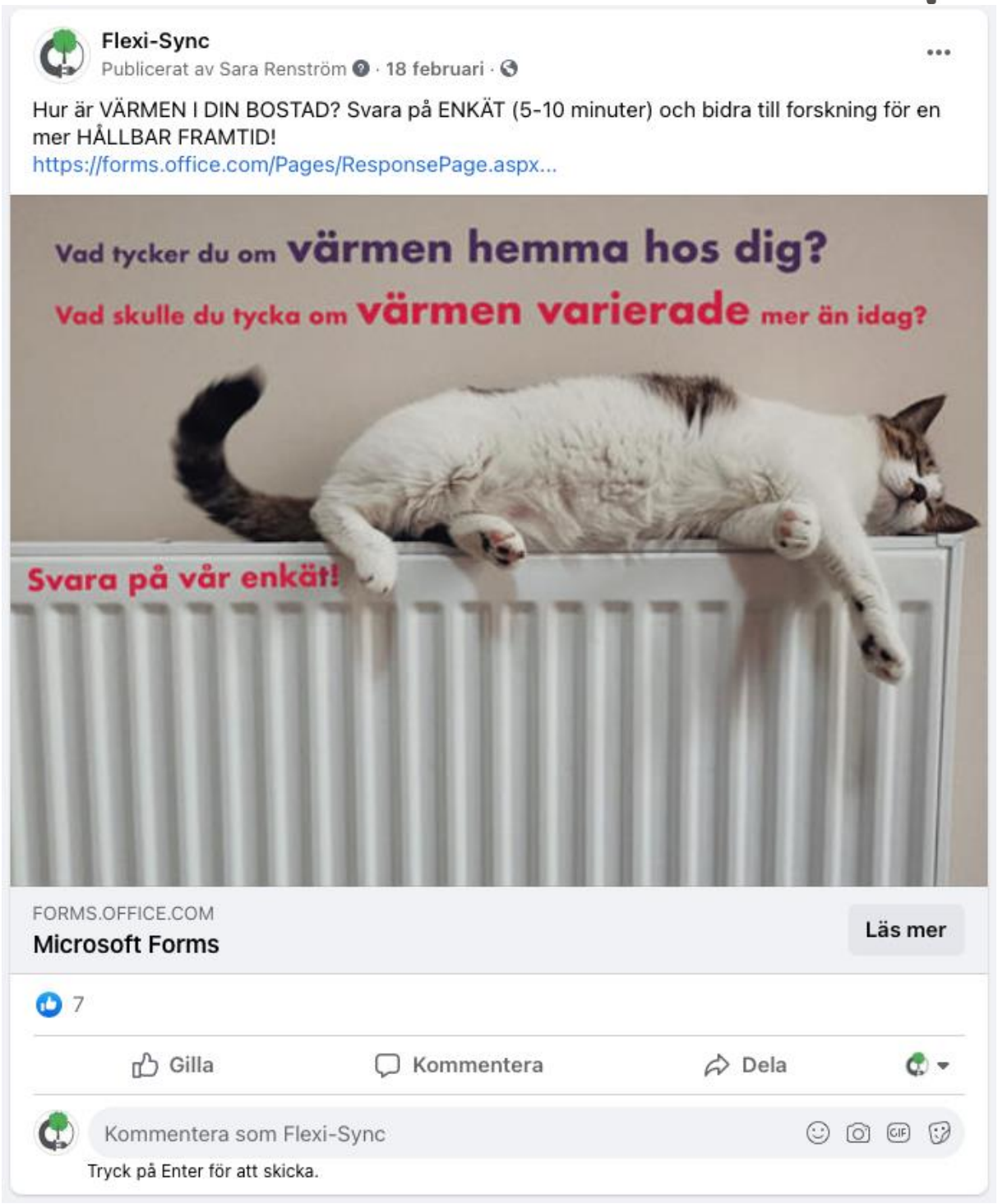


Figure 3. The Facebook advertisement.

4.1.3 Data analysis

As the survey had a very low response rate, all results must be analysed and interpreted with great caution. Therefore, our findings cannot be generalised and should be seen as insights about the 88 survey respondents. As the sample size was small and the data was not random, we conducted descriptive statistics.

The assessment was done to answer the points mentioned in section 4.1.1 Table 2. Accordingly, the relationship between scenario preference and age, gender, ownership

type, current satisfaction with heating were investigated. Furthermore, the correlation between temperature changes and the current heating satisfaction, age, gender, how the heating is paid, etc. were assessed. These points showed how flexibility acceptance is changing among different factors such as technical, social, demographic. In the survey, many questions were followed by space for optional free-text comments (see 4.2.1). These comments were summarised thematically and used to complement the qualitative findings and to find indications of possible correlations.

4.2 Findings from survey

Scenario 3 – You decide how much variation you think is okay was the most preferred scenario by the respondents and 57% of the respondents were positive or quite positive towards it and 23% neutral about it, see Figures 4a and 4b. Scenario 2 – A little more variation that is extra good for the environment the second most preferred one (see Figure 4a), but on the other hand 42% were quite negative or negative towards it (see Figure 4b). The third most preferred option was keeping it the way it is right now, see Figure 4a. Scenario 1 was only 9% of the respondents' favourite option, but on the other hand 21% were positive or quite positive and 45% neutral about it; a scenario that is not the preferred one for a large share of the respondents but still is accepted by a majority. Figure 4b shows the acceptance level of all three scenarios.

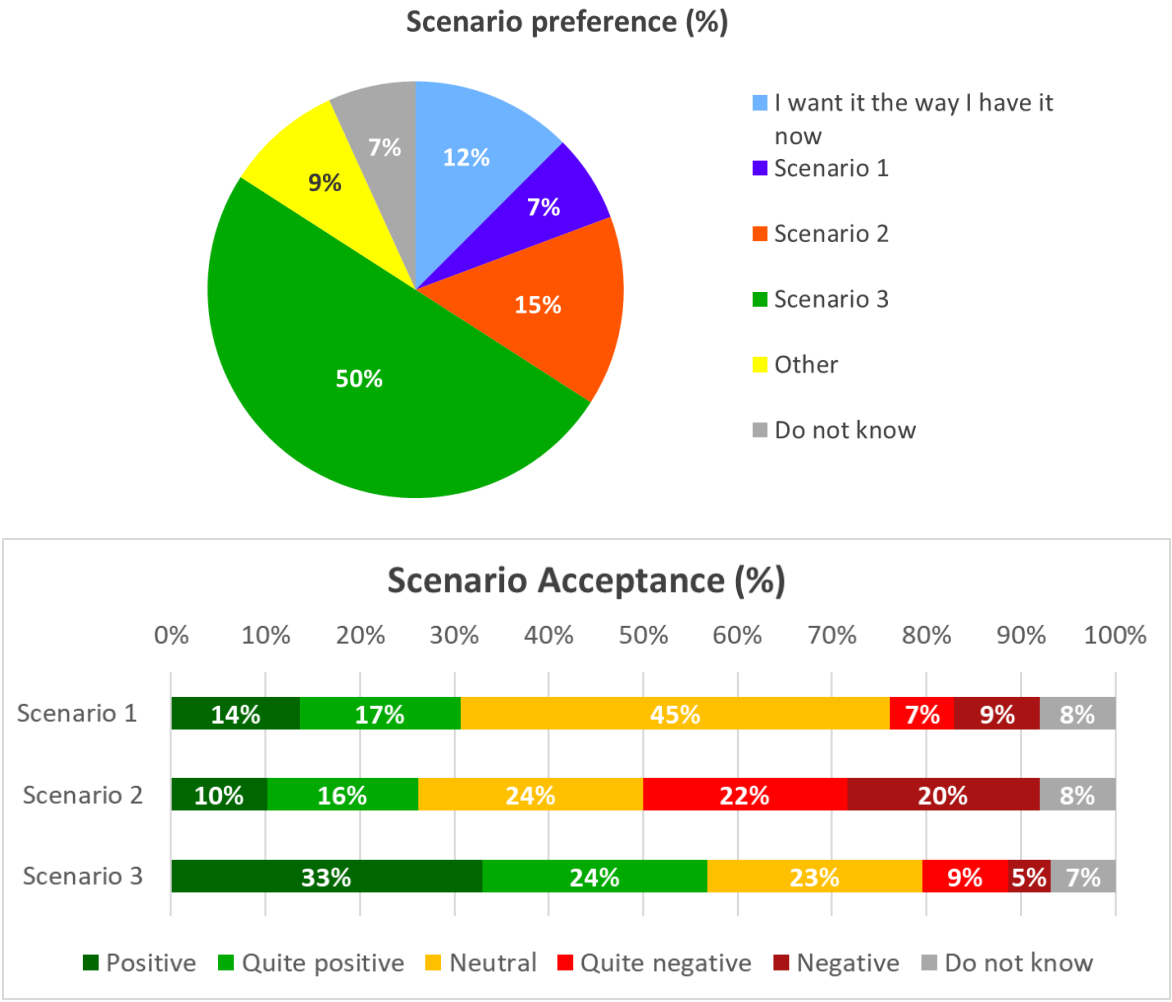


Figure 4a (top), Figure 4b (bottom) Distribution of preferred scenario (top) and acceptance level of all three scenarios (bottom).

Figure 5 below shows how respondents believed that they will be affected by increased variation in indoor temperature within different temperature spans. It is worth noting that some respondents think that they would be negatively affected already with ±0.5°C, which might influence their perception of Scenario 1, although previous findings suggest otherwise (see literature review). In the optional free-text follow-up question regarding ±0.5°C almost all comments (n=13) stated that +0.5°C would not at all be a problem but they were afraid of freezing (even more) with a decrease of 0.5°C. Figure 5 as well as the comments reveal the fear of being cold at home the larger temperature span that is suggested, for example including comments about having to wear outdoor clothes indoors (at ±1.5°C and ±2°C) and rebound showering to keep warm (one respondent, suggestion already at -0.5°C and indicated increased showering at -2°C). Even though there are fewer comments about fear of feeling too warm, this concern was mentioned already at +1°C but more at +1.5°C and +2°C.

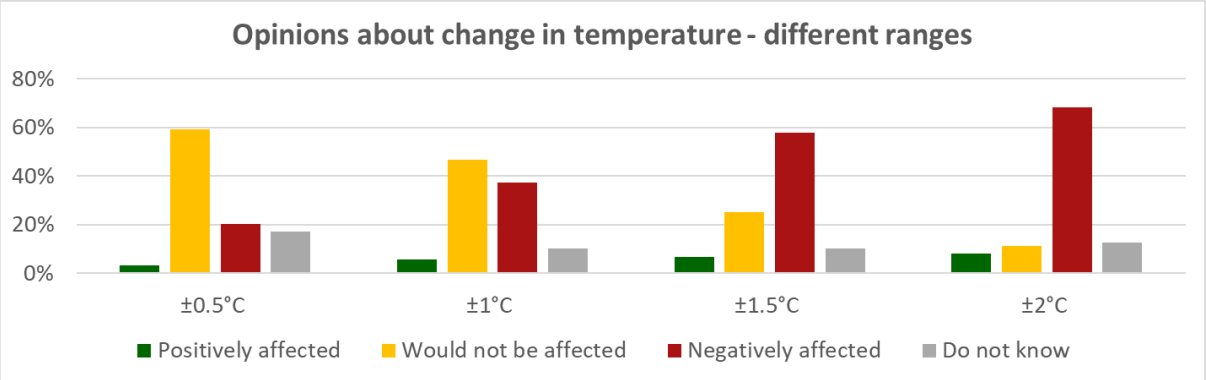


Figure 5. Respondents' belief of if and how they would be affected by increased variation in indoor temperature within different temperature spans.

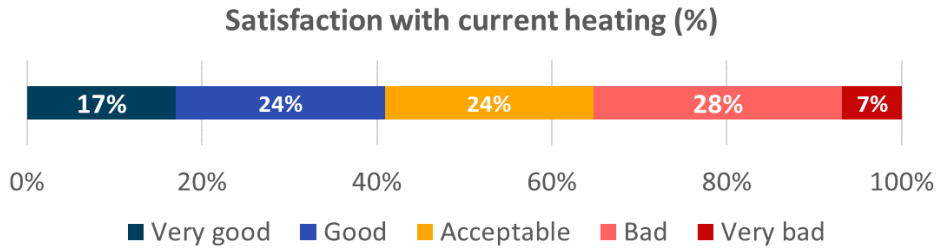


Figure 6 Share of how satisfied the respondents are with the current heating in their homes

In Figure 6 what do the respondents think about their heating is shown. The comments about fear of being too cold indicate a possible connection between satisfaction with current heating and the believed impact of increased variation in indoor temperature. Thus, the relationship between respondents' opinions about their heating and the different temperature changes were investigated. Figure 7a to Figure 7d show the opinion about current heating (from very bad to very good) in relation to the believed impact of increased variation in indoor temperature. Based on these results, respondents seem more negative towards larger variations the more dissatisfied they are with their current heating.

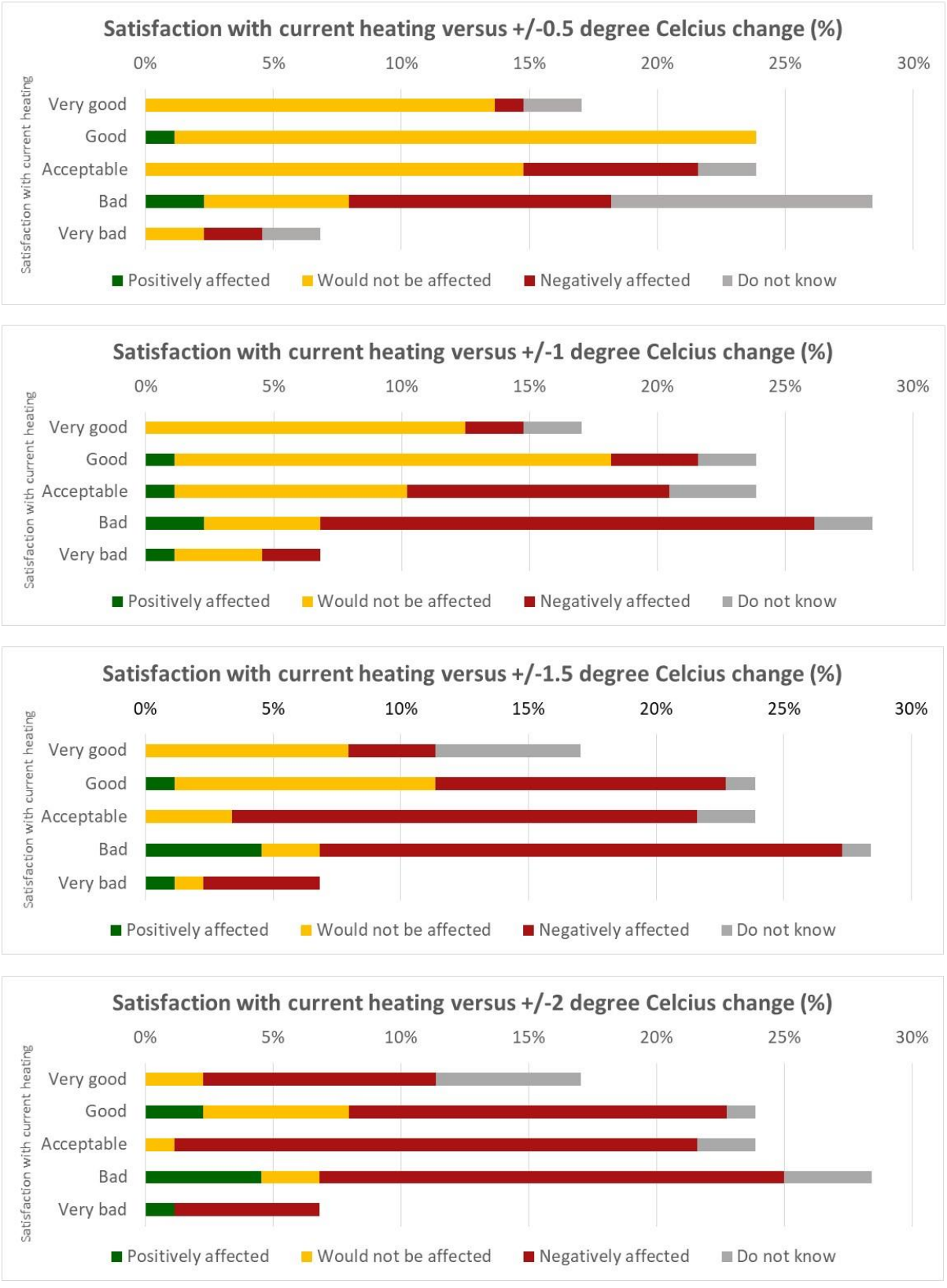
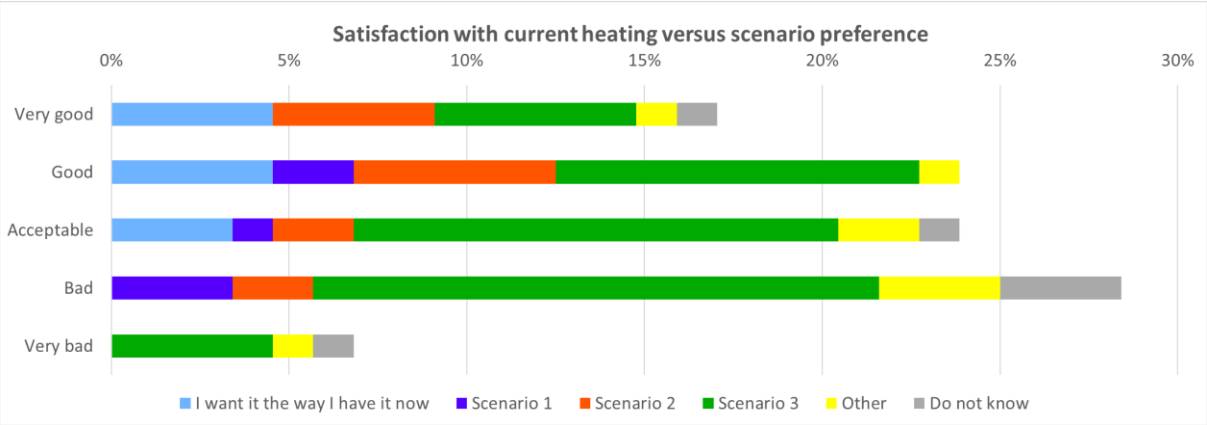
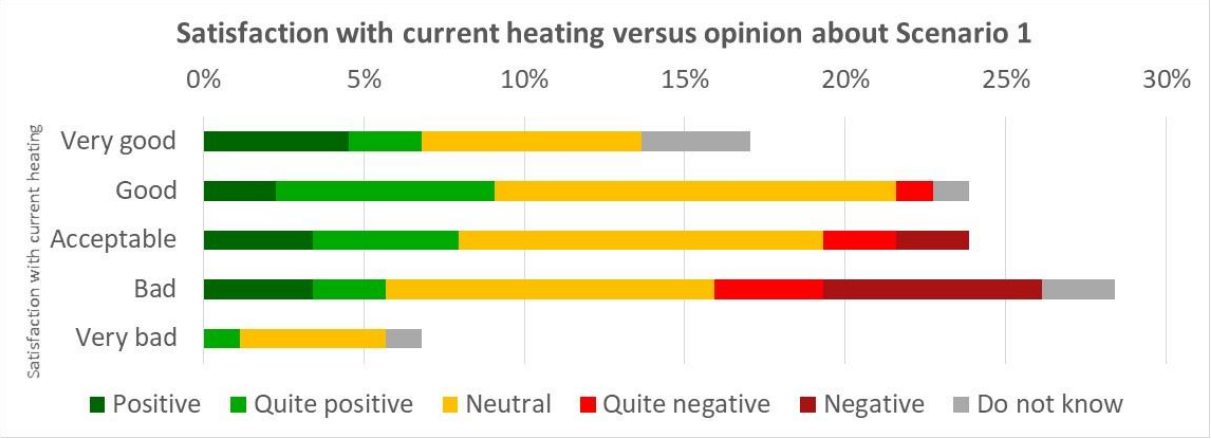
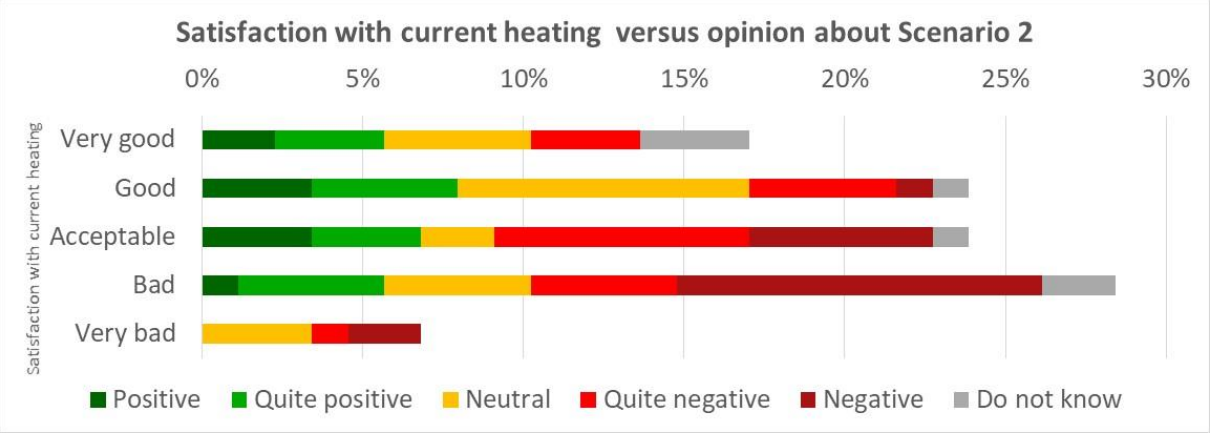


Figure 7a (top) to Figure 7d (bottom). Respondents' opinions about their current heating in relation to the believed impact of increased variation in indoor temperature from ±0.5°C (top) to ±2°C (bottom).

As the three scenarios have different temperature ranges, fear of deterioration of the heating from an already unsatisfactory level could influence the preferred scenario and the acceptance of the different scenarios. Figure 8a to Figure 8d shows satisfaction with current heating in relation to scenario preference (Figure 8a) and acceptance of the three scenarios (Figure 8b to Figure 8d).







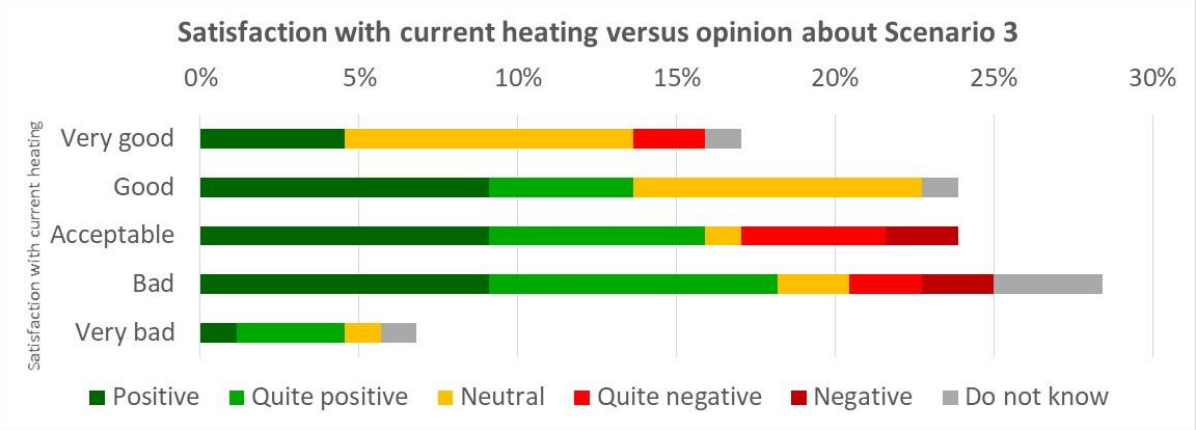
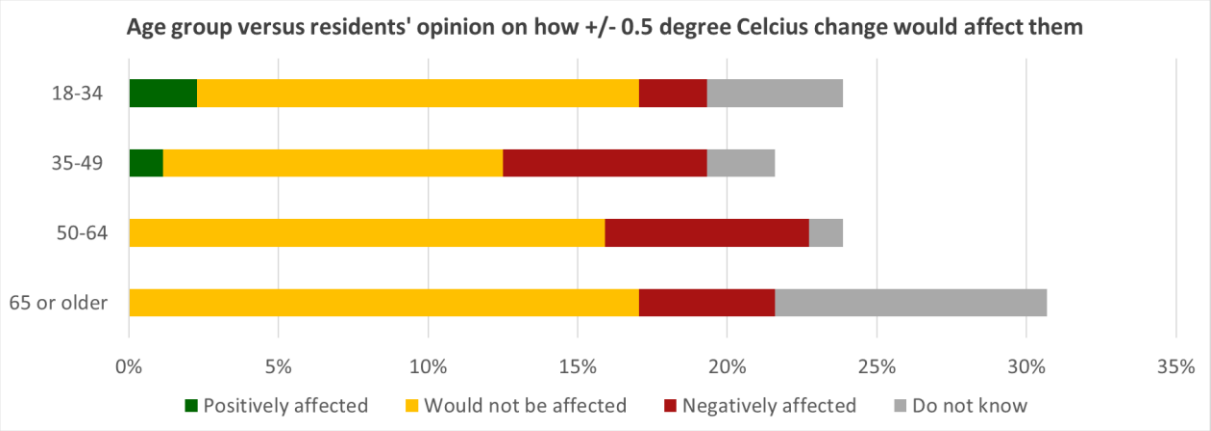
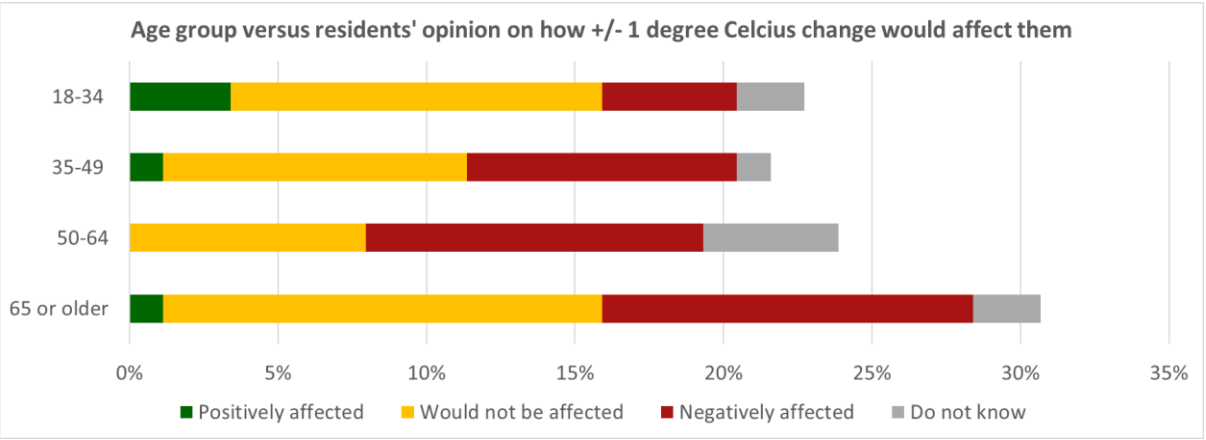
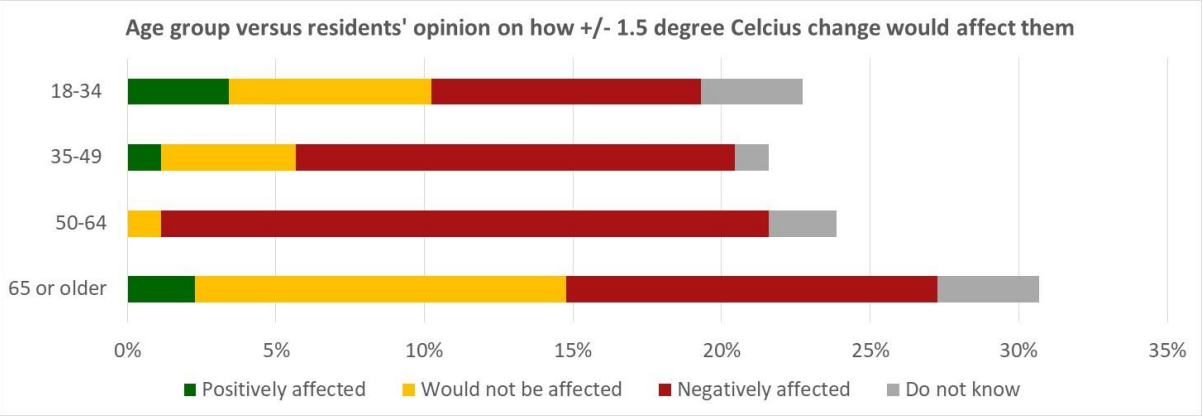


Figure 8a (top) to Figure 8d (bottom). Satisfaction with current heating concerning scenario preference (top) and acceptance of the three scenarios (bottom three).

Previous findings and comments indicate that increased age might be related to an increased need for heating, as metabolism and mobility might decrease, and time spent at home might increase when retired. But in this sample, there seems to be no such correlation between age and respondents' belief of if and how they would be affected by increased variation in indoor temperature within different temperature spans, see Figure 9a to Figure 9d.







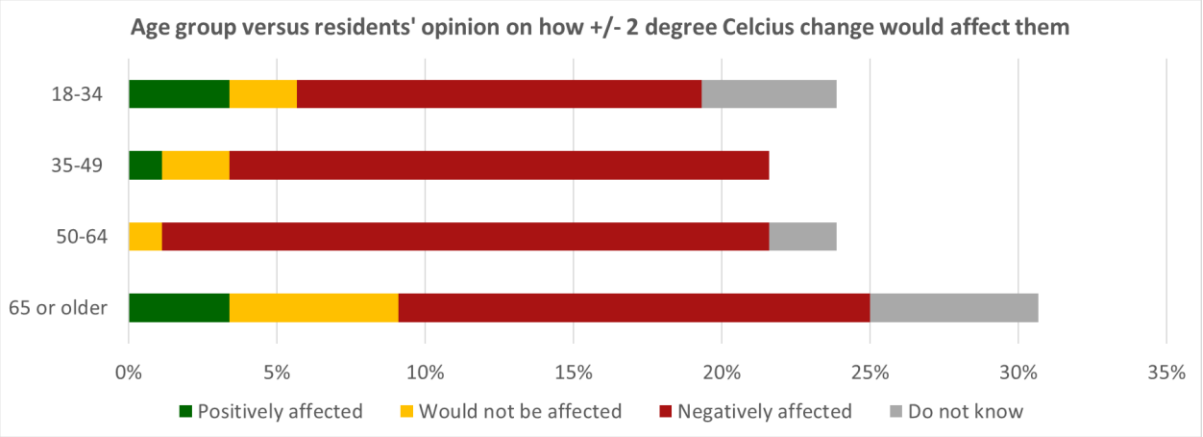


Figure 9a (top) to Figure 9d (bottom). Age in relation to respondents' belief of if and how they would be affected by increased variation in indoor temperature within different temperature spans, from ±0.5°C (top) and ±2°C (bottom).

Age in relation to which scenario is the most preferred, see Figure 10, indicated that Scenario 3 is the most preferred option in which residents' have more control over their heating, however, among 18-34 years old's Scenario 2 is the most preferred option after Scenario 3 that the residents have no control over the temperature variation.

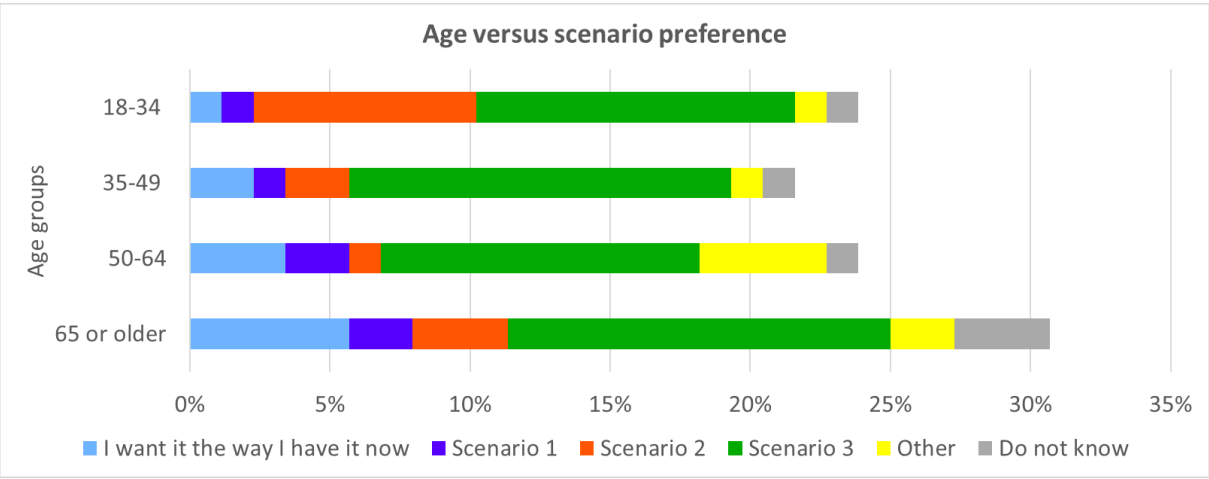


Figure 10. Age in relation to scenario preference.

4.2.1 Free text comments in the survey

As mentioned, the survey had several options for free-text answers and comments as a complement or follow-up to multiple-choice questions. Answering these free-text questions was optional and the number of respondents thus varied for each question. But the answers anyhow give ideas about why the respondents answered the multiple-choice questions as they did.

In the first free-text question, the respondents were asked to comment on their current heating. Of the 88 respondents, 45 wrote a comment. Of these 45 comments, 16 respondents expressed that it is too cold, it could be better, that they feel a draft and experience cold floors. The bathroom was specifically mentioned as too cold by three respondents. Five respondents expressly wrote that the heating and radiators are not sufficient and some mention using complements such as heating fans and tea candles. Some also expressed that they wanted a high temperature. For example, one respondent wanted between 23 and 27°C s/he worked (presumably from home) with sedentary tasks. At the same time, 5 responded that the heating is good and that it sometimes even gets too warm – the seasons are one of the contributors to this.

Most of the text responses for the questions on how a variation of ±0.5°C to ±2°C would affect the respondents 18 answered that they don't want a lower temperature. A lot of them feel that it is already too cold, and a colder temperature wouldn't be comfortable. 17 responded that this kind of variation will affect the body, would be noticeable and that it's too big of a variation. "I am already cold inside" is one of 13 responses that all agree that this kind of variation would lead to them being cold inside. "Do you want to force me to wear outerwear indoors to survive" was another comment that expresses the fear of freezing. A few answers reflect that some people are at home all day, and maybe due to old age, sickness or sedentary tasks can experience this variation in a greater way than others. Six respondents wrote that an increase in temperature is okay, but not a decrease. So, for example, +1°C would be acceptable but not -1°C (cf. pre-heat vs. temperature drop in Le Dréau & Heiselberg, 2016).

There were in total 19 answers to a question about what could be improved with Scenario 1. Eight of them included a wish to be informed and the importance of information. One respondent wrote that s/he wanted "Information and part of the profit". Other respondents wrote that they want to be able to have some control over the temperature, both regarding regulation for different rooms, depending on weather, but also the time of day.

Of the 88 respondents, 18 gave suggestions for improvement for or commented on Scenario 2. Four of them expressed that 18°C is too cold, even if it's only for 48 hours and that this should lead to rent deduction. 19°C or 19.5°C was expressed as the minimum ac acceptable temperature by two respondents. Three answered that they wish for a more even temperature and that such temperature variations as in Scenario 2 are not desirable. One respondent was sceptical about the efficiency of such reductions: "It is too expensive to heat up [the space] after the reduction. You save 0 on the reduction!". One other respondent wanted to learn about the usefulness of Scenario 2, for example, that the residents save X kWh or contribute to cutting peaks in demand.

Regarding Scenario 3, the question about improvements to the scenario was by mistake omitted in the online version. But there was an open question right after Scenario 3 in which respondents commented on Scenario 3 as well as more general issues. These comments were equally distributed among three overreaching themes, the respondents want freedom of choice, they think a variation in temperature is fine, but they also express concerns about the consequences if it's too cold. Some of the mentioned consequences express that a temperature variation may be very different for different residents, such as people with rheumatism, people with problematic sinuses, people who don't have warm jobs to go to or people that are just colder than others. Taking more and longer hot showers was mentioned as a possible rebound effect.

Freedom of choice implies that they can control the temperature in individual rooms, when not at home but also just the simple fact and power to change the temperature. The comments also reflect the individual preferences that residents have regarding heating, for example, for one variation in the day was acceptable but not during the night as her/his sleep would be affected negatively.

One respondent was very sceptical to the whole idea with more flexible heating, and with energy-saving overall. The respondent pointed to the need to realise that Sweden is a cold country and that we need to produce more energy than we are doing. The politicians should not phase out any energy production units until the production of environmentally friendly electricity meets or exceeds the need for energy. This comment, as well as the comment regarding that nothing is saved with variation as it takes more energy to heat up the space after a temperature drop, point to the difficulty of explaining flexible heating. First, the difference between district heating and electricity needs to be clearer and then the difference between energy-saving and flexibility, i.e., peak-cutting and valley-filling.

5 WORKSHOP: END-USER FLEXIBILITY POTENTIAL IN AUSTRIA

Due to different preconditions in different countries in Europe it was not possible to distribute the same survey to several countries. So, to add to the predominately Swedish perspective in Sections 3 and 4 above, this section describes a stakeholder workshop at the demonstration site in Maria Laach am Jauerling, Austria.

5.1 Method

During a stakeholder workshop at the Austrian demonstration site in Maria Laach am Jauerling, opinions, wishes and needs of the participants were requested regarding the flexibilization of the local heating network. The participants of the workshop consisted of stakeholders from:

- The local municipality of Maria Laach,
- Office of the Lower Austrian (Niederösterreich -NÖ) Government Department for Spatial Planning, Environment and Mobility,
- Lower Austrian Chamber of Agriculture -Department Renewable Energy,
- Bioenergie NÖ (Cooperative association for construction and operation of bioenergy heat supply system)
- Bio-heat association (Biowärmeverband NÖ) and
- Beck& partner KG (consulting company on demand side management)
- District heating Costumers (Hotel/Restaurant)

The questions, among others, were related to consumer satisfaction regarding heat supply, buildings as possible flexibility options (using the building mass as a thermal storage) and the participant's willingness to offer flexibility to the electricity and heating grid.

5.2 Findings from stakeholder workshop

The following section introduces the questions asked during the workshop to the nine participants (excluding project partners), displays the opinions as graphs and summarizes the answers given.

5.2.1 Question 1

Question 1 covered status quo:

- How satisfied are customers with the current local heating supply in Lower Austria?
  (If unsatisfied: the suppliers or the end-customers see potential for improvement)

Figure 11. Response to question 1 covering status quo

Over 50% of the respondents answered the question with 'very satisfied' or 'mostly satisfied', see Figure 11. Neutrally or negatively are seen the heating costs, customer service and price transparency. It was seen as a limitation that connection of off grid customers is often not possible. It can be seen that the participants are predominantly satisfied with the heating supply in Maria Laach am Jauerling.

5.2.2 Questions 2

Questions 2 covered flexibility options in local heating grids:

- 1) Do buildings as thermal storage facilities play a comparable role to traditional storages?
- 2) And are you or your customers willing to accept a loss of comfort in buildings (e.g. temperature)?
- 3) What role does digitalization play in this context (concretely: Would you be in favor of an energy management system or information communication technology system in your building)?

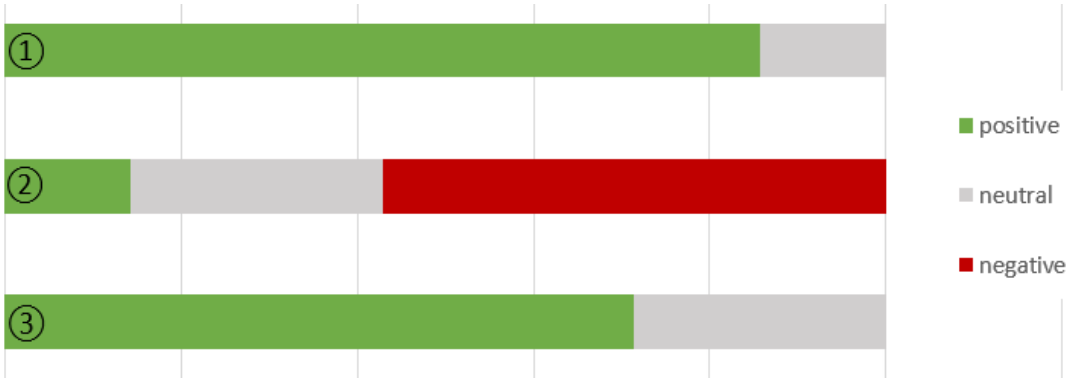


Figure 12. Response to questions 2 covering flexibility

Over 70% of the participants see a great potential for buildings to offer flexibility (question 1), whereas digitalization plays a big role (question 3). This can be seen in Figure 12. However, nearly 60% of participants answered that no comfort loss is desired or accepted. The information for customers is seen as important and two price models (variable tariff) are conceivable for the participants. Different pricing models that incentivize the offering of flexibility (and resulting comfort losses) could enhance approval of the concept. Additionally, it was states as a barrier that multiple buildings may not be suitable as thermal storages due to lightweight construction.

5.2.3 Question 3

Question 2 covered business models:

- Would it be interesting to provide consumer-side flexibilities (load reduction, hot water storage, possible heat pumps, etc.) for a cheaper heat price?

Figure 13. Response to question 3 covering business models

This question was predominantly answered with 'yes' (over 70%), whereas profitability is seen to be an important factor, for both the heating grid operators as well as the customers, see Figure 13. The price design is considered to be a difficult topic due to the challenge of a new billing procedure and transparency.

6 DISCUSSION & CONCLUSION

6.1 Discussion on methodological issues

As mentioned, the low response rate on the survey makes generalisations from the result impossible. Yet, we do think that these insights are possible indications or interesting hypotheses about the wider population. These possible indications or hypotheses of course need to be rejected or confirmed in future studies. They will in the conclusion below be presented as suggestions for further investigations. Some of the findings from the survey corroborate previous literature findings. For such findings, the survey result can be seen as examples that help deepen the understanding of these phenomena.

Concerning the workshop on end-user flexibility in Austria, the small number of participants is not representative for general and far-reaching statements. However, the answers depict views not only from household customers but from businesses (hotel, restaurant), the heat supplier and policy makers.

6.2 Discussions on findings

In the questionnaires, the respondents preferred flexibility setups in which they have control over the flexibility range and are compensated economically for ranges larger than ±0.5°C (Scenario 3) over flexibility setups with the same variation and no control (Scenario 1) and larger variations without control (Scenario 2). It is important to keep in mind that although most people should not (cf. Fanger, 1970) be affected by ±0.5°C some survey respondents think that they will be affected and this could influence their acceptance of, for example, Scenario 1. But it is anyhow not surprising that Scenario 3 was the most preferred one; it gives occupants' control and economic incentives. Many previous studies have shown that giving occupants' control over heating is very important for satisfaction, in setups with varying indoor temperature as well as in studies without varying indoor temperature (e.g., Bauman, Carter, & Baughman, 1998; Boerstra, Loomans, & Hensen, 2013; de Dear et al., 2013; Hagejärd et al., 2021; Renström, 2016; Sweetnam et al., 2019). Economic incentives have previously been shown to result in interest in participation in flexibility programs (Sweetnam et al., 2019).

On the other hand, it is surprising that more survey respondents had Scenario 2 as the preferred scenario than Scenario 1. There are no comments from the survey respondent that would indicate why that is. Some of them commented that, due to their apartments currently being too cold, +1°C would be appreciated, but Scenario 2 also means that there will be -1°C at times. But, if we look at the acceptance rates of Scenario 1 and Scenario 2, 31% were positive or quite positive and 45% were neutral to Scenario 1, while fewer were positive and neutral to Scenario 2, 26% were positive or quite positive and 24% were neutral (see Figure 4a and Figure 4b). Scenario 1 was acceptable to a majority of the respondents but not their preferred option. Scenarios 1 and 3 are actually quite similar in terms of temperature ranges, but Scenario 2 provides control over flexibility and the option to get economically compensated for increased temperature ranges. Yet, it is still interesting that 15% of the respondents are willing to accept Scenario 2, a scenario that probably would affect their comfort, especially on cold days, without any economic compensation. Just like it is found in previous studies by Renström (Renström, 2019b, 2019a), there are residents that are willing to make compromises for the sake of

the environment. Interestingly, younger respondents (aged 18 to 34) showed the highest acceptance rate of Scenario 2. Renström's studies also included participants in that age group (Renström, 2019b, 2019a). But there are not enough complementary studies to draw any conclusions. What needs to be researched further – if this correlation proves to holds – is if it is related to the age, meaning that younger respondents always are like that, or if it is related to that generation and will hold also when these respondents grow older.

In the survey responses, the level of satisfaction with current heating seemed to influence scenario preference and maybe also acceptance rate of each of the scenarios (see Figure 8a to Figure 8d). Among the respondents that found their current heating bad or very bad, Scenario 3 was more preferred than among other respondents. The respondents that found their current heating to be good or very good Scenario 2 was more preferred than among other respondents (although Scenario 3 was still the most preferred option). When it comes to satisfaction of current heating in relation to believed impact of increased variation in indoor temperature (see Figure 7a to Figure 7d), level of satisfaction also seemed to influence the believed impact. The less satisfied, the more negative impact increased variations were believed to have. No similar insight has been found in other studies, but Hagejärd et al. (2021) point to the importance of addressing causes of dissatisfaction with the heating, such as poor insulation or insufficient ventilation, in relation to the flexibility program to increase the overall satisfaction. It is also not surprising that residents are a bit sceptical towards greater variation and less control if they already are dissatisfied.

The results from the workshop show that the participants are predominantly satisfied with the heating supply in Maria Laach am Jauerling. Buildings as heating storages and the use of digitalization in buildings was seen as favourable. However, comfort losses within the buildings are not desired. Innovative pricing models that incentivize flexibility could enhance approval of possible comfort losses.

6.3 Conclusions

Findings in literature that were corroborated by survey findings:

- Flexibility is difficult to explain and to understand – but it is important to do so (cf. Sweetnam et al., 2019).
- There is more than temperature range that is important for residents, for example location and time of day (cf. Christensen et al., 2020; Sweetnam et al., 2019).
- Residents have specific and individual preferences in relation to heating, for example acceptable for high variations during night but not in the morning (cf. Renström & Rahe, 2013).
- Control over temperature and flexibility is very attractive to residents (cf. Sweetnam et al., 2019).

- Some residents have very energy intensive expectations on heating, e.g. wanting between 23 and 27°C (cf. Renström & Rahe, 2013).
- Pricing models that incentivize the use of building mass as flexibility could enhance the acceptance rate of (minor) comfort losses within buildings (cf. Sweetnam et al., 2019).

Possible indications or tentative hypothesis based on survey findings, to be confirmed or rejected in future studies

- Residents prefer flexibility setups in which they have control over the flexibility range and are compensated economically for ranges larger than ±0.5°C (Scenario 3) over flexibility setups with the same variation and no control (Scenario 1) and larger variations without control (Scenario 2).
- Residents want to be informed also about flexibility setups that (theoretically (cf. Fanger, 1973)) do not affect their comfort – such as Scenario 1.
- Some residents are willing to accept a deterioration of the heating service – as in Scenario 2 – without any compensation.
- In the survey, younger residents (age 18-34) show the highest acceptance of Scenario 2.
- In the survey, how satisfied you are with the current heating seems to influence the extent to which you accept higher variations in indoor temperature.
- If you spend more time at home, you will have higher demands on thermal comfort, e.g., if you are working from home just as many have been during the Covid-19 outbreak.

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8 ANNEX A – QUESTIONNAIRE

8.1 Questionnaire in English

Heating in your home - now and in the future

Hello!

With this survey, we want to find out what you think about the heating in you homes. We also want to learn about what you think of changing the heating in their homes to make the production of heat cheaper and better for the environment. The survey is conducted by two Swedish research institutes, RISE and IVL, in collaboration with housing and energy companies in a European research project. You can read more about the research project and the survey here: https://www.flexisync.eu/projektwebbar/flexi-sync/news/flexisync-news-archive/2021-01-13-what-do-residents-think-of-flexible-district-energy.html
The results of the survey will also be used by Mälardalen University to understand how new technical solutions are spread in society. The answers to the questionnaire are collected by RISE and your answers are completely anonymous.

Section 1
Questions about the home where you mainly live

1.Which type of dwelling do you live in?
Applies to the dwelling where you mainly live.
Flat
Townhouse, semi-detached house or terrace-house
Detached villa / cottage

2. What form of lease does the dwelling have?
Applies to the home where you mainly live.
Tenancy
Condominium
Ownership (if you own (part of) an apartment, villa or cottage)

3. Approximately how many square meters is the dwelling?
Applies to the dwelling where you mainly live.

4. How many people live in the home, including yourself?
Count on all adults and children living in the home at least half the time. Applies to the home where you mainly live.

5. How many of those living in the home are under 18 years old?
Count on everyone under the age of 18 living in the home at least half the time. Applies to the home where you mainly live.

6.Approximately how many hours on weekdays does no one stay at home?

Choose the option that suits you best right now, even if COVID-19 has affected how much you are away. Applies to the home where you mainly live
0-4 hours
5-9 hours
10 hours or more

7. What type of heating system does the dwelling have?
You can select several options. Applies to the home where you mainly live.
District heating
Heat pump, e.g. ground source heat pump or air heat pump
Boiler
Direct electricity
Fireplaces in the home
Do not know

8. What is the main heating technology used in the dwelling?
You can select several options. Applies to the dwelling where you mainly live.
Radiators
Underfloor heating
Electric radiators
Fireplace e.g. wood-burning stove or tiled stove
Do not know

9.How is the heating paid where you live?
Applies to the dwelling where you mainly live.

10.What do you think about heating comfort in general in your dwelling?
Applies to the home where you mainly live.

11.Do you have any comments about the heating comfort in your dwelling?

Section 2
Questions about varying temperatures in the home

If the room temperature in apartments varies a little more than it does today, it is possible to produce the energy - that is heat, hot water and electricity - for homes in a way that is cheaper and better for the environment. Read down here if you want to know why!

For example, extra energy is often needed for hot water and some electricity used in the mornings. By heating the apartments a little less in the mornings, energy use becomes more even throughout the day. To prevent getting cold at home, apartments can be "preheated" at night and "reheated" after morning. The room temperature may then vary a little more than today. These are small temperature differences and the temperature still varies depending on, for example, how many people are at home, what appliances are used, ventilation and whether the sun is shining. The control of the variation in temperature needs to be combined with measurements of indoor temperature. Therefore, the

temperature comfort is improved in many cases, even though a limited variation in temperature is allowed.

.....

12. The heat can vary differently over or below your current room temperature (in addition to the natural variation that already occurs during a day due to, for example, ventilation). How do you think you would be affected if the heat in your current home varied by ...

... at most 0.5 degrees above or below your current room temperature?

13. Please describe how you would be affected by a 0.5 degree variation above or below the current room temperature.

14. ... at most 1 degree above or below your current room temperature?

15. Please describe how you would be affected by a 1 degree variation above or below the current room temperature.

16. ... at most 1.5 degrees above or below your current room temperature?

17. Please describe how you would be affected by a 1.5 degree variation above or below the current room temperature.

18. ... at most 2 degrees above or below your current room temperature?

19. Please describe how you would be affected by a 2 degree variation above or below the current room temperature.

Section 3
Questions about different options for varying heat

We have made three options that describe different ways in which the heat can vary. Read the three options and reflect on how you think! These three options are written as if you are a tenant living in a rental apartment. If you do not do that, you can imagine what you would think if you lived in a rental apartment.

20. Option 1 - Small variation that does not affect comfort

In this option, without affecting your comfort, the heat in the apartment building that you live in is optimized with the goal of using energy in a way that is better for the environment. Temperature measurement equipment is installed in some apartments that make it possible to follow, and in some cases, improve indoor comfort. Certain controlled temperature variation is allowed and for most apartments that means more variation than today. The average room temperature is the same as before. The controlled variation of the room temperature in Option 1 is at most 0.5 degrees above or below your current room temperature (apart from natural variations in temperature due to, for

example, ventilation). It is the same variation in the whole building and both day and night. You and the other tenants do not receive any information that the housing and energy company are trying to heat the apartments in this way as research has shown that such small variations do not affect comfort.

What is your attitude towards Option 1 being introduced in your rental apartment or if you lived in a rental apartment?

21. Is there anything you want to change in Option 1 to make it better for you?

22. Option 2 - A little more variety that is extra good for the environment

In this option, the heating in the building that you live in is adapted with the goal of using energy in a way that is better for the environment. Temperature measurement equipment is installed in some apartments that make it possible to follow, and in some cases, improve indoor comfort. Certain controlled temperature variation is allowed and for most apartments that means more variation than today. The average room temperature is the same as before. The controlled variation of the room temperature in Option 2 is at most 1 degree above or below your current room temperature (apart from natural variations in temperature due to, for example, ventilation) most of the time. From midnight to 5 o'clock in the morning, the temperature varies at most 1.5 degrees above or below your current room temperature. The energy provision is the most strained and more dependent on fossil fuels when the weather is at its coldest. To use as little fossil energy as possible, the room temperature varies more on really cold days. But the temperature must never be lower than 18 degrees. It may be so for 48 hours at the longest and at most, it may be 10 such days in a year. You will be notified in advance when such cold days are approaching. You and the other tenants are told that the temperature now varies a little more than before and how the variation is distributed over the day. You will find out that this is something many buildings in Sweden do together to use as much climate-smart energy as possible.

What is your attitude towards Option 2 being introduced in your rental apartment or if you lived in a rental apartment?

23. Is there anything you want to change in Option 2 to make it better for you?

24. Option 3 - You decide how much variety you think is okay

In this option, you move to a newly built apartment where new technology makes it possible for you and the other tenants to adjust your heating yourself. The goal is to heat the home in a way that is better for the environment. When you live in this apartment, you can choose to what extent you want to contribute to this goal. In Option 3, you choose how much controlled temperature variation that you accept, from 0.5 degrees to 3 degrees above or below your current indoor temperature (apart from natural variations in temperature that depend on, for example, ventilation). You receive information about how and to what extent the temperature variation that you and the other tenants provide contributes to the environment. You also get a financial bonus if you choose to have

more variation than 0.5 degrees, from 200 SEK to 500 SEK per year depending on how much variation that you accept. You decide whether the variation in temperature should be the same all the time or if you want the variation to be greater or less, for example during nights or when no one is at home. You can also have different variations in different rooms, for example in bedrooms and bathrooms. The energy provision is the most strained and more dependent on fossil fuels when the weather is at its coldest. To use as little fossil energy as possible, on really cold days, you will be notified that extra temperature variation would be favorable. You decide whether you accept this or not. The temperature is never allowed to be lower than 18 degrees. You and the other tenants get to know how the heating works and it is easy to control the variation yourself, for example through an app.

What is your attitude towards having Option 3 if you moved to a new rental apartment?

25. What would you like the most in your rental apartment or if you lived in a rental apartment?
I want it the way I have it now
As Option 1 - Small variation that does not affect comfort
As Option 2 - A little more variety that is extra good for the environment
As Option 3 - You decide how much variety you think is okay
Do not know

26. Do you have any comments regarding varying heat?

Section 4
Questions about you

27. How old are you?

28. What do you identify as?
Woman
Man
Non-binary
Another option
Uncertain

29. Where were you born?
In Sweden
Outside of Sweden
Do not want to answer

30. In which part of Sweden do you live?
Norrland
Svealand
Götaland
I do not live in Sweden

31. In one year, approximately how much is your household's disposable income? By that, we mean salary, student grants and loans, grants and other types of income after tax for everyone in your household.

32. What is your highest level of education?

Section 5
Thank so much for your responses!

33. If you have any additional comments, please add them below.

8.2 Questionnaire in Swedish

Svenska

Värmen i din bostad – nu och i framtiden

Hej! Med den här enkäten vill vi ta reda på vad du tycker om värmen hemma. Vi vill också ta reda på vad du tycker om att förändra värmen i sin bostad för att produktionen av värme ska bli billigare och bättre för miljön.

Enkäten genomförs av två svenska forskningsinstitut, RISE och IVL, i samarbete med bostads- och energibolag i ett europeiskt forskningsprojekt. Du kan läsa mer om forskningsprojektet och enkäten här: https://www.flexisync.eu/projektwebbar/flexi-sync/news/flexisync-news-archive/2021-01-13-what-do-residents-think-of-flexible-district-energy.html (https://www.flexisync.eu/projektwebbar/flexi-sync/news/flexisync-news-archive/2021-01-13-what-do-residents-think-of-flexible-district-energy.html) Resultatet av enkäten kommer också användas av Mälardalens högskola för att förstå hur nya tekniska lösningar sprids i samhället.

Svaren på frågorna samlas in av RISE och dina svar är helt anonyma.

* Obligatoriskt

Frågor om bostaden där du huvudsakligen bor

1. Vilken typ av bostad bor du i? *

Gäller bostaden där du huvudsakligen bor.

- Lägenhet
- Radhus, parhus eller kedjehus
- Fristående villa/stuga
- Annat

1/27/2021

2. Vilken upplåtelseform har bostaden? *

Gäller bostaden där du huvudsakligen bor.

- ○ Hyresrätt
- ○ Bostadsrätt
- ○ Äganderätt (om du äger (del av) lägenhet, villa eller stuga)
- ○ Annat

3. Ungefär hur många kvadratmeter är bostaden? *

Gäller bostaden där du huvudsakligen bor.

- ○ Mindre än 30 kvadratmeter
- ○ 30 – 60 kvadratmeter
- ○ 60 – 90 kvadratmeter
- ○ 90 –120 kvadratmeter
- ○ 120 – 150 kvadratmeter
- ○ Mer än 150 kvadratmeter

4. Hur många bor i bostaden inklusive dig själv? *

Räkna med alla vuxna och barn som bor i bostaden minst hälften av tiden. Gäller bostaden där du huvudsakligen bor.

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5 eller fler

1/27/2021

5. Hur många av de som bor i bostaden är under 18 år gamla? *

Räkna med alla under 18 år som bor i bostaden minst hälften av tiden. Gäller bostaden där du huvudsakligen bor.

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5 eller fler

6. Ungefär hur många timmar under vardagar är det ingen som vistas i bostaden? *

Välj det alternativ som stämmer bäst just nu även om covid-19 påverkat hur mycket du/ni är borta. Gäller bostaden där du huvudsakligen bor.

- ○ 0-4 timmar
- ○ 5-9 timmar
- ○ 10 timmar eller mer

1/27/2021

7. Vilket typ av uppvärmningssystem har bostaden? *

Du kan välja flera alternativ. Gäller bostaden där du huvudsakligen bor.

- [ ] Fjärrvärme
- [ ] Värmepump, t ex bergvärmepump eller luftvärmepump
- [ ] Värmepanna
- [ ] Direktverkande el
- [ ] Eldstäder i bostaden
- [ ] Vet ej
- [ ] Annat

8. Hur värms bostaden huvudsakligen? *

Du kan välja flera alternativ. Gäller bostaden där du huvudsakligen bor.

- [ ] Vattenburen radiatorvärme (element som värms med vatten)
- [ ] Golvvärme
- [ ] El-radiatorer (element som värms med el)
- [ ] Eldstad t ex vedeldad kamin eller kakelugn
- [ ] Vet ej
- [ ] Annat

1/27/2021

9. Hur betalas värmen där du bor? *

Gäller bostaden där du huvudsakligen bor.

- ○ Värmekostnaden är inkluderad i hyran/avgiften
- ○ Värmekostnaden är inkluderad i hyran/avgiften men varmvatten betalas separat
- ○ Värmekostnaden betalas separat
- ○ Vet ej
- ○ Annat

10. Hur tycker du att värmekomforten i stort sett är i din bostad? *

Gäller bostaden där du huvudsakligen bor.

- ○ Mycket dålig
- ○ Dålig
- ○ Acceptabel
- ○ Bra
- ○ Mycket bra
- ○ Vet ej

11. Har du några kommentarer kring värmekomforten i din bostad?

1/27/2021

Frågor om varierande temperatur i bostaden

Om rumstemperaturen i bostäder varierar lite mer än den gör idag så går det att producera energin – alltså värme, varmvatten och el – till bostäder på ett sätt som är billigare och bättre för miljön. Läs här nere om du vill veta varför!

.....

Till exempel på morgnar behövs ofta extra mycket energi till det varmvatten och den el som används på morgnarna. Genom att värma lägenheterna lite mindre på morgnarna blir energianvändningen jämnare över dagen. För att det inte ska bli kallt hemma kan lägenheter "förvärmas" på natten och "eftervärmas" efter morgonen. Rumstemperaturen kan då komma att variera lite mer än idag. Det rör sig om små temperaturskillnader och temperaturen varierar ändå beroende på till exempel hur många som är hemma, vilka apparater som används, vädring och om solen skiner in.

För att styra variationen av temperatur behöver styrningen kombineras med mätningar av inomhustemperatur. Det gör att temperaturkomforten i många fall förbättras mot vad den var tidigare, även om en viss kontrollerad temperaturvariation tillåts.

.....

12. Värmen kan variera olika mycket över och under din nuvarande rumstemperatur (utöver den naturliga variation som redan sker under en dag till följd av till exempel vädring).

    Hur tror du att du skulle påverkas om värmen i din nuvarande bostad varierade med ...

    ... som mest 0,5 grader över eller under din nuvarande rumstemperatur? *

    - ○ Jag skulle påverkas negativt
    - ○ Jag skulle inte påverkas
    - ○ Jag skulle påverkas positivt
    - ○ Vet ej
    - ○ Annat

13. Beskriv gärna hur du skulle påverkas av 0,5 graders variation över eller under nuvarande rumstemperatur.

1/27/2021

14. ... som mest 1 grad över eller under din nuvarande rumstemperatur? *

- Jag skulle påverkas negativt
- Jag skulle inte påverkas
- Jag skulle påverkas positivt
- Vet ej
- Annat

15. Beskriv gärna hur du skulle påverkas av 1 grads variation över eller under nuvarande rumstemperatur.

16. ... som mest 1,5 grader över eller under din nuvarande rumstemperatur? *

- Jag skulle påverkas negativt
- Jag skulle inte påverkas
- Jag skulle påverkas positivt
- Vet ej
- Annat

17. Beskriv gärna hur du skulle påverkas av 1,5 graders variation över eller under nuvarande rumstemperatur.

1/27/2021

18. ... som mest 2 grader över eller under din nuvarande rumstemperatur? *

- ○ Jag skulle påverkas negativt
- ○ Jag skulle inte påverkas
- ○ Jag skulle påverkas positivt
- ○ Vet ej
- ○ Annat

19. Beskriv gärna hur du skulle påverkas av 2 graders variation över eller under nuvarande rumstemperatur.

1/27/2021

Frågor om olika alternativ för varierande värme

Vi har gjort tre alternativ som beskriver olika sätt som värmen kan variera på. Läs de tre alternativen och fundera över vad du tycker!

De här tre alternativen är skrivna som om du bodde i en hyreslägenhet. Gör du inte det får du föreställa dig vad du skulle tycka om du bodde i en hyreslägenhet.

20. Alternativ 1 – Liten variation som inte påverkar komforten

.....

I det här alternativet optimeras uppvärmningen i huset där du bor med målet att använda energi på ett sätt som är bättre för miljön utan att påverka din inomhuskomfort negativt. Temperaturmätning installeras i en del lägenheter som gör det möjligt att följa upp och i vissa fall förbättra inomhuskomforten för hela byggnaden. En viss kontrollerad temperaturvariation tillåts, för en del lägenheter kan det innebära högre variation än idag. Den genomsnittliga rumstemperaturen är samma som innan.

I Alternativ 1 är den kontrollerade variationen i temperatur som mest 0,5 grader över eller under din nuvarande rumstemperatur (bortsett från naturliga variationer i temperatur som beror på till exempel vädring). Det är samma variation i hela byggnaden och samma variation både dag och natt.

Du och de andra hyresgästerna får ingen information om att bostads- och energibolaget försöker värma lägenheterna på det här sättet eftersom forskning visat att sådan liten variation inte påverkar komforten.

.....

Hur ställer du dig till att Alternativ 1 skulle införas i din hyreslägenhet eller om du bodde i en hyreslägenhet? *

- ○ Negativ
- ○ Ganska negativ
- ○ Neutral
- ○ Ganska positiv
- ○ Positiv
- ○ Vet ej

1/27/2021

21. Finns det något som du vill ändra i Alternativ 1 för att det ska passa dig bättre?

1/27/2021

22. Alternativ 2 – Lite mer variation som är extra bra för miljön

.....

I det här alternativet anpassas uppvärmningen i huset där du bor med målet är att använda energi på ett sätt som är bättre för miljön. Temperaturmätning installeras i en del lägenheter som gör det möjligt att följa upp och i vissa fall förbättra inomhuskomforten. En viss kontrollerad temperaturvariation tillåts, för de flesta lägenheter innebär det högre variation än idag. Den genomsnittliga rumstemperaturen är samma som innan.

I Alternativ 2 är den kontrollerade variationen i temperatur som tillåts som mest 1 grad över eller under din nuvarande rumstemperatur (bortsett från naturliga variationer i temperatur som beror på till exempel vädring) under största delen av dygnet. Från midnatt till klockan 5 på morgonen varierar temperaturen som mest 1,5 grader över eller under din nuvarande rumstemperatur.

När det är som kallast ute är energiförsörjningen oftast som mest ansträngd och mer beroende av fossila bränslen. För att använda så lite fossil energi som möjligt varierar rumstemperaturen mer riktigt kalla dagar. Men temperaturen får aldrig vara lägre än 18 grader. Det får vara så i 48 timmar som längst och som mest får det vara 10 sådana dagar på ett år. Om det blir en sådan kall dag kommer du få meddelande om det i förväg.

Du och de andra hyresgästerna får veta att temperaturen nu varierar lite mer än förut och hur variationen ser ut över dygnet. Ni får veta att det här är något många byggnader i Sverige gör för att tillsammans använda så klimatsmart energi som möjligt.

.....

Hur ställer du dig till att Alternativ 2 skulle införas i din hyreslägenhet eller om du bodde i en hyreslägenhet? *

- ○ Negativ
- ○ Ganska negativ
- ○ Neutral
- ○ Ganska positiv
- ○ Positiv
- ○ Vet ej

1/27/2021

23. Finns det något som du vill ändra i Alternativ 2 för att det ska passa dig bättre?

1/27/2021

24. Alternativ 3 – Du bestämmer hur mycket variation du tycker är okej

.....

I det här alternativet flyttar du till en nybyggd lägenhet där ny teknik gör det möjligt för dig och de andra boende att själva anpassa er uppvärmning. Målet är att värma upp bostaden på ett sätt som är bättre för miljön. Du som bor här kan själv välja hur mycket du vill bidra till det målet.

I Alternativ 3 väljer du hur mycket kontrollerad temperaturvariation du tycker är okej, från 0,5 grader till 3 grader över eller under din nuvarande rumstemperatur (bortsett från naturliga variationer i temperatur som beror på till exempel vädring). Du får information hur din och andra hyresgästers variation i temperatur bidrar till miljön. Du får också en ekonomisk bonus om du väljer att ha mer variation än 0,5 grader, från 200 till 500 kronor per år beroende på hur mycket variation du accepterar.

Du bestämmer om variationen i temperatur ska vara samma hela tiden eller om du vill att variationen ska vara större eller mindre till exempel under nätter eller under tider när ingen är hemma. Du kan också ha olika variation i olika rum, till exempel i sovrum och badrum.

När det är som kallast ute är energiförsörjningen oftast som mest ansträngd och mer beroende av fossila bränslen. För att använda så lite fossil energi som möjligt sådana dagar får du då ett meddelande om att det vore bra om du kunde tillåta en större temperaturvariation. Du väljer själv om du går med på det. Temperaturen får aldrig vara lägre än 18 grader.

Du och de andra hyresgästerna får information om hur värmen funkar och det är lätt att själva styra variationen, till exempel genom en app.

.....

Hur ställer du dig till att Alternativ 3 skulle finnas om du flyttade till en ny hyreslägenhet? *

- ○ Negativ
- ○ Ganska negativ
- ○ Neutral
- ○ Ganska positiv
- ○ Positiv
- ○ Vet ej

1/27/2021

25. Hur skulle du helst vilja ha det i din hyreslägenhet eller om du bodde i en hyreslägenhet? *

- ○ Jag vill ha det så som jag har det nu
- ○ Som Alternativ 1 – Liten variation som inte påverkar komforten
- ○ Som Alternativ 2 – Lite mer variation som är extra bra för miljön
- ○ Som Alternativ 3 – Du bestämmer hur mycket variation du tycker är okej
- ○ Vet ej
- ○ Annat

26. Har du några kommentarer gällande varierande värme?

1/27/2021

Frågor om dig

27. Hur gammal är du? *

- under 18 år
- 18-34 år
- 35-49 år
- 50-64
- 65 eller äldre

28. Vad identifierar du dig som? *

- Kvinna
- Man
- Ickebinär
- Annat alternativ
- Osäker

29. Var är du född? *

- I Sverige
- Utanför Sverige
- Vill ej svara

1/27/2021

30. I vilken del av Sverige bor du? *

- Norrland
- Svealand
- Götaland
- Bor inte i Sverige
- Annat

31. Under ett år, ungefär hur stor är ditt hushålls disponibla inkomst? *

Med det menar vi lön, studiebidrag och -lån, bidrag och andra typer av inkomst efter skatt för alla i ditt hushåll.

- Under 100 000 kr
- 100 000 – 199 999 kr
- 200 000 – 299 999 kr
- 300 000 – 399 999 kr
- 400 000 – 499 999 kr
- 500 000 – 599 999 kr
- 600 000 kr eller mer
- Vill ej svara

1/27/2021

32. Vilken är din högsta utbildningsnivå? *

- ○ Mindre än grundskolenivå
- ○ Grundskola, realskola, folkskola eller motsvarande
- ○ Gymnasium, folkhögskola eller motsvarande
- ○ Universitet, högskola eller motsvarande

1/27/2021

Stort tack för dina svar!

33. Om du har fler kommentarer får du gärna skriva dem nedan.

Det här innehållet har inte skapats och stöds inte av Microsoft. Data du skickar kommer att skickas till formulärets ägare.

Microsoft Forms

1/27/2021

9 ANNEX B – SCENARIOS IN SWEDISH

9.1 Alternativ 1 – Liten variation som inte påverkar komforten

I det här alternativet optimeras uppvärmningen i huset där du bor med målet att använda energi på ett sätt som är bättre för miljön utan att påverka din inomhuskomfort negativt. Temperaturmätning installeras i en del lägenheter som gör det möjligt att följa upp och i vissa fall förbättra inomhuskomforten för hela byggnaden. En viss kontrollerad temperaturvariation tillåts, för en del lägenheter kan det innebära högre variation än idag. Den genomsnittliga rumstemperaturen är samma som innan.

I Alternativ 1 är den kontrollerade variationen i temperatur som mest 0,5 grader över eller under din nuvarande rumstemperatur (bortsett från naturliga variationer i temperatur som beror på till exempel vädring). Det är samma variation i hela byggnaden och samma variation både dag och natt.

Du och de andra hyresgästerna får ingen information om att bostads- och energibolaget försöker värma lägenheterna på det här sättet eftersom forskning visat att sådan liten variation inte påverkar komforten.

9.2 Alternativ 2 – Lite mer variation som är extra bra för miljön

I det här alternativet anpassas uppvärmningen i huset där du bor med målet är att använda energi på ett sätt som är bättre för miljön. Temperaturmätning installeras i en del lägenheter som gör det möjligt att följa upp och i vissa fall förbättra inomhuskomforten. En viss kontrollerad temperaturvariation tillåts, för de flesta lägenheter innebär det högre variation än idag. Den genomsnittliga rumstemperaturen är samma som innan.

I Alternativ 2 är den kontrollerade variationen i temperatur som tillåts som mest 1 grad över eller under din nuvarande rumstemperatur (bortsett från naturliga variationer i temperatur som beror på till exempel vädring) under största delen av dygnet. Från midnatt till klockan 5 på morgonen varierar temperaturen som mest 1,5 grader över eller under din nuvarande rumstemperatur.

När det är som kallast ute är energiförsörjningen oftast som mest ansträngd och mer beroende av fossila bränslen. För att använda så lite fossil energi som möjligt varierar rumstemperaturen mer riktigt kalla dagar. Men temperaturen får aldrig vara lägre än 18 grader. Det får vara så i 48 timmar som längst och som mest får det vara 10 sådana dagar på ett år. Om det blir en sådan kall dag kommer du få meddelande om det i förväg.

Du och de andra hyresgästerna får veta att temperaturen nu varierar lite mer än förut och hur variationen ser ut över dygnet. Ni får veta att det här är något många byggnader i Sverige gör för att tillsammans använda så klimatsmart energi som möjligt.

9.3 Alternativ 3 – Du bestämmer hur mycket variation du tycker är okej

I det här alternativet flyttar du till en nybyggd lägenhet där ny teknik gör det möjligt för dig och de andra boende att själva anpassa er uppvärmning. Målet är att värma upp bostaden på

ett sätt som är bättre för miljön. Du som bor här kan själv välja hur mycket du vill bidra till det målet.

I Alternativ 3 väljer du hur mycket kontrollerad temperaturvariation du tycker är okej, från 0,5 grader till 3 grader över eller under din nuvarande rumstemperatur (bortsett från naturliga variationer i temperatur som beror på till exempel vädring). Du får information hur din och andra hyresgästers variation i temperatur bidrar till miljön. Du får också en ekonomisk bonus om du väljer att ha mer variation än 0,5 grader, från 200 till 500 kronor per år beroende på hur mycket variation du accepterar.

Du bestämmer om variationen i temperatur ska vara samma hela tiden eller om du vill att variationen ska vara större eller mindre till exempel under nätter eller under tider när ingen är hemma. Du kan också ha olika variation i olika rum, till exempel i sovrum och badrum.

När det är som kallast ute är energiförsörjningen oftast som mest ansträngd och mer beroende av fossila bränslen. För att använda så lite fossil energi som möjligt sådana dagar får du då ett meddelande om att det vore bra om du kunde tillåta en större temperaturvariation. Du väljer själv om du går med på det. Temperaturen får aldrig vara lägre än 18 grader.

Du och de andra hyresgästerna får information om hur värmen funkar och det är lätt att själva styra variationen, till exempel genom en app.

10 ANNEX C – QUESTIONNAIRE INVITATION FLYERS

Ge din åsikt om framtidens värme i lägenheter!

Vi försöker göra produktion av värme till lägenheter billigare och bättre för miljön. Vill du hjälpa oss genom att svara på en enkät? Enkäten tar cirka 10 minuter att svara på.

Alla som svarar har chans att vinna ett SuperPresentkort på 250 kr!

Enkäten besvarar du på dator, mobil eller surfplatta. Använd länken eller QR-koden nedan.

https://tinyurl.com/survey-rise-heating

Mer om enkäten

Med enkäten vill vi ta reda på vad boende tycker om värmen hemma. Vi vill också ta reda på vad boende tycker om att förändra värmen i sin bostad för att produktionen av värme ska bli billigare och bättre för miljön. Enkäten genomförs av två svenska forskningsinstitut, RISE och IVL, i samarbete med bostads- och energibolag inom ramen för ett europeiskt forskningsprojekt. Ett av bostadsbolagen i samarbetet är din hyresvärd Eskilstuna Kommunfastigheter. Mer information finns där du hittar enkäten.

Vid frågor kontakta Sara Renström, RISE: sara.renstrom@ri.se eller 010 228 42 14.

Share your view on future heating in apartments!

We are trying to make the production of heat for apartments cheaper and better for the environment. Help us by responding to a survey. It will take you around 10 minutes to do so.

All survey respondents can win 250 SEK in a gift card from SuperPresentkortet.

You respond to the survey on computer, smart phone or tablet. Use the link or QR-code below.

https://tinyurl.com/survey-rise-heating

More information about the survey

With this survey, we want to find out what tenants think about heating in their homes. We also want to learn what tenants think about changing the heating to make the heat production cheaper and better for the environment. The survey is conducted by two Swedish research institutes, RISE, and IVL, together with housing and energy companies within a European research project. One of the housing companies is your landlord Eskilstuna Kommunfastigheter. There is more information in the survey.

Questions can be directed to Sara Renström, RISE: sara.renstrom@ri.se or 010 228 42 14.

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